

# Chemical & Process Engineering

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## Topics of the Month

### The Alkali Inspectors on the chemical industry

AN excellent 'inside' survey of the economic as well as the technical health of the British chemical and allied industries is always given in the annual reports of the alkali inspectors, making this Government publication far more interesting than its somewhat misleading title suggests.\* The 1953 report, just issued, is no exception and we learn that last year demand for sulphuric acid, nitric acid, dyestuffs, pharmaceuticals, chlorine, nylon and other commodities exceeded supply and that many further plant expansions are planned. The great demand for cement resulted in all productive capacity being hard pressed and the iron and steel and coal carbonisation industries also worked in top gear. The tinplate industry made a remarkable recovery in the later months of the year; zinc was in good demand; superphosphate sales were probably lower than in 1952 because it seems that farmers are now buying fertilisers only as and when they are required for immediate application rather than holding supplies in their own stores.

The production in 1953 of 1,683,000 tons of sulphuric acid, by both the chamber and contact processes, is the highest figure yet recorded and an increase of 331,000 tons over 1952. While the increase in the amount of brimstone sulphur burned is slight in comparison with 1952, that of

\*Ninetieth Annual Report on Alkali, etc., Works by the Chief Inspectors, 1953. H.M.S.O. 2s. 6d. net.

spent oxide is substantial and that of pyrites has been almost doubled.

There has been a considerable increase in the amount of acid made by the contact process, most of it due to the coming into operation of new units based on the flash roasting of pyrites. A number of units for the production of acid from anhydrite are under construction. Some apprehension is felt in the industry on account of the increasing bitumen content of the sulphur available for acid making. Blockages of hot gas filters and an increase in the mistiness of the final escapes are forecast.

In Scotland there were only three contact acid plants in use throughout the year, but another one was in course of construction. Shortage of sulphur still appears to influence the use of this type of plant and the new one is designed to use pyrites.

Fifteen works in England and Wales are registered as alkali works because of decomposition of common salt or, to a much less extent, of muriate of potash. The 'wet-copper' process, wherein copper ores (usually burnt pyrites) are roasted with common salt, is no longer practised in England and Wales. A total of 57,700 tons of salt were used in the saltcake process in 1953, compared with 55,600 tons in 1952, 61,000 tons in 1951 and 73,000 tons in 1950. These figures include a small amount of potassium chloride. Two works were jointly responsible for 28,000 tons in 1953.

The high demand for cement of the past few years continued throughout 1953 and kilns have been operated intensively with shut-downs only as and when required for necessary repairs or overhauls. On Thames-side, where about half the cement in the country is produced, dust emission creates a formidable problem which is to some extent insoluble. The national demand for cement is such as to necessitate the operation of the kilns at full output even when dust arrestment plants are faulty or are undergoing repairs.

The number of works registered under the Alkali, etc., Works Regulation Act, 1906, in 1953 was 950, involving the operation of 1,775 separate processes. Compared with 1952, there were decreases of 14 in the number of works and of 10 in the number of separate processes.

During the year the inspectors made 3,936 visits and inspections of works in England and Wales, of which 376 were to or in connection with works not registered under the Alkali Act and 106 to or in connection with spoilbanks. During the inspections 1,950 quantitative analyses were made of gases evolved from the processes in operation and 205 special samples were drawn and submitted for detailed examination to the Government Chemist.

### South African chemicals and explosives

THE new South African factory for making ammonia, nitric acid and ammonium nitrate described elsewhere in this issue comes into production at a time when the huge Sasol oil-from-coal project is near completion. The two undertakings mark an interesting stage in the development of South Africa's chemical industry. The Modderfontein ammonia factory typifies the close link there has always been between the production of commercial explosives and the production of heavy chemicals in the Union, while the Sasol plant gives promise of a host of chemical by-products hitherto not made in the Union.

South Africa's heavy chemical and explosives industries originated at the same time because in order to manufacture commercial explosives economically it is essential for many of the basic ingredients to be produced within the same organisation. The starting up of a synthetic ammonia plant at Modderfontein in 1932 was an important landmark in the development of these twin industries. Formerly the Union was largely dependent for its nitric acid requirements on imported supplies of Chilean saltpetre, which was treated with sulphuric acid. The synthesis plant has enabled demand to be met economically from local sources. It also made possible the introduction of ammon gelignites and ammon dynamites, which did much to reduce the cost of explosives to the mining industries. The new facilities at Modderfontein are additional to the older plant.

Turning to the other side of the picture, we can see in the by-products from the Sasol enterprise (the project was fully described in *CHEMICAL & PROCESS ENGINEERING*, 1954, 35 (5), 153-155) the foundation of a completely new chemical industry in the Union. These by-products will provide raw materials for numerous new undertakings and many of them, either as produced by Sasol or in reprocessed form, may find export markets and thereby earn valuable foreign exchange. The coal gasification plant alone will produce 9,000 tons p.a. of ammonia liquor—equivalent to two-thirds of South Africa's nitrogenous fertiliser imports for 1950—12,000 tons of low-temperature tar and 6,000 tons of tar acids p.a.

### Fatty alcohols by high-pressure hydrogenation

FATTY alcohols of the lauryl alcohol type have hitherto been imported into this country. An indigenous source of supply of these materials, which are used largely in detergents, has now been established by Marchon Products Ltd. at their Whitehaven, Cumberland, factory. The new plant has a capacity of 4,000 tons p.a. of fatty alcohols and it cost £500,000, being erected by the firm's own engineers. There are four chief routes to fatty alcohols:

From sperm oil by saponification and subsequent distillation;

From natural fats by reduction with metallic sodium or by high-pressure hydrogenation;

From olefines by chlor addition and soda saponification, or by direct oxidation, or by the 'Oxo' synthesis;

Synthetically from carbon monoxide and hydrogen.

The process most used by the Americans, who are probably the largest producers of fatty alcohols, is the sodium reduction of natural fats. This is the result of an abundance of metallic sodium at an economic price. In Europe there is no such availability of sodium metal and consequently the process is uneconomic.

The process chosen by Marchon Products is the high-pressure hydrogenation of fats. The plant has been designed for maximum flexibility and can use as raw materials vegetable oils, tallow, fatty acids or fatty acid esters. It consists of five main sections each of which can be operated separately, although the whole is run as a continuous unit. In the first section the catalyst—copper chromite—is made from copper and nitric acid. Hydrogen is produced in the second section of the plant by the electrolysis of dilute caustic soda solution in Knowles-type cells. In the third section the fatty acid esters are made by reacting together fatty alcohols and fatty acids. Hydrogenation takes place in the fourth section of the plant, where esters are mixed with catalyst to form a paste. This paste is pumped at 4,000 to 5,000 p.s.i. into stainless steel-lined autoclaves together with hydrogen.

In this way the esters are converted into fatty alcohols at a temperature of about 300°C. After filtering off the catalyst the crude fatty alcohol goes to storage, from whence it goes to the fifth and final section of the plant, where it is fractionally distilled under high vacuum in a Dowtherm heated column which can produce any specific alcohol at a purity of 99%. Half the final product alcohol is returned to the ester plant for production of the initial ester, the other half going to aluminium storage tanks.

The Marchon project heralds a significant change in the raw materials balance of the British detergents industry, for the large-scale production anticipated makes possible an increase in the manufacture of detergents based on fatty alcohols as distinct from petroleum-derived alkyl aryl sulphonates. It is on these latter products that the bulk of the household detergent industry is now based, following the expansion of the petroleum refining industry in Britain. Alkyl aryl sulphonates, of course, will continue to provide the bulk of raw materials for household detergent manufacture.

Marchon have launched their venture in anticipation of an increase in total detergent consumption and the development of new uses. It is on such products as shampoos that they pin their hopes, not unnaturally in view of the fact that 90% of British shampoos are made with fatty alcohol sulphates.



"FAT PROCESSING"

### New fabricating techniques

AN inevitable accompaniment to changing production techniques is the constant search for new materials of construction, and for new ways of using existing materials, to meet the new conditions. With this there is a striving after new ways of bending, shaping and otherwise working both old and new materials. Two new forming processes—one for rigid vinyl plastics and the other for aluminium—illustrate the latter tendency well. The first, a new approach to the rapid forming of rigid vinyl plastics by using conventional metal stamping equipment, seems destined to have far-reaching effects in the fabricating industries. In the new method, developed by the B. F. Goodrich Chemical Co., a fast conveyor belt takes the plastic sheet from a pre-heating oven to the conventional metal stamping press which forms the finished shape. It is claimed that no additional operations are necessary to complete the end-product.

If the process is all that is claimed, there will be no need for expensive moulding machines and slow hand-operated draw-forming or blow-forming presses such as are needed to process rigid vinyl plastic at present. This could enable metal-working firms to diversify their operations and move into the plastics field with little capital outlay.

The other new development, which also promises to have considerable repercussions in its field, is a new process for the precision-forming of metal parts from aluminium sheets and forging stock by immersion in chemical solutions. Known as the *Chem-Mill* process, it is designed to replace the milling machine in many operations. It is claimed to offer, for the first time, contouring without the application of any physical force. Parts emerge from the chemical bath smooth and perfectly formed. Equipment costs are said to be low and facilities can be quickly installed. The process was originated by North American Aviation Co. and developed in conjunction with Turco Products Inc., manufacturers of industrial chemical compounds. By agreement with North American, Turco is licensed to make the process available to other manufacturing companies. Patents are pending.

### Uranium in 1953

URANIUM is probably the world's most valuable strategic metal and with the progress being made in Britain, the U.S. and Russia in the production of nuclear power for industry its economic importance is also increasing. Thus, a recent German estimate of world uranium production is unusually interesting. The estimate, given by G. Kruse in the June issue of *Chemische Industrie*, places last year's global output of pure uranium metal at 9,070 tons. Nearly one-half (4,450 tons) were produced in the Belgian Congo, where, mainly owing to heavy American purchases, it has already become necessary to use uranium ore of poorer metal content. In contrast, the ore deposits in certain parts of the British Commonwealth (Australia, Rhodesia, South Africa) have only just begun to be exploited, so that they are likely to play a greater part in the future. Canadian production in 1953 is estimated at 1,440 tons of pure uranium, and the total production in the countries of the British Commonwealth at 1,750 tons.

The United States, though by far the greatest consumers of uranium, have extensive but comparatively low-grade uranium deposits within their own territory. Production in 1953 is estimated at 1,200 tons. In addition, North American capital is invested in uranium mines in South America and Central America, which have, however, only produced about 20 tons. American capital is also concerned with the exploitation of mines in Portugal and Portuguese East Africa, which are estimated to have yielded 250 tons of uranium in 1953.

In Europe, France is the only country with major uranium ore deposits, especially near Limoges, St. Sylvestre and Le Bouchet. Those at Limoges, which have only been exploited for four years, are said to be the most valuable uranium deposits in the world. French production in 1953 is estimated at 100 tons. There are minor deposits in Spain, Italy and Western Germany. Recent finds of uranium ore have been made in Norway and Sweden. But the 1953 production of these countries together hardly amounted to more than 30 tons. In 1953, therefore, the countries of the Western world produced about 7,800 tons of uranium.

There are no reliable figures available for uranium production in Communist countries. However, from the best sources available, it is estimated that Soviet Russia produced about 900 tons, Czechoslovakia 300 tons, Eastern Germany 50 tons, Bulgaria 10 tons and China 10 tons, a total of 1,270 tons. However, these countries have far greater reserves of hitherto untapped uranium ore deposits, so that the production figures are likely to shift in favour of the Communist countries.

### Petrochemicals grow fast in Southern U.S.A.

READILY available petroleum and natural gas, plus low-cost water transportation to markets, have led to the large new concentrations of chemical activity in the Gulf south-west area in the U.S.A., and particularly in the Houston industrial area. In 1952 total investment in chemical plants in a 100-mile wide belt of the Texas Gulf Coast extending from the Sabine River to the Rio Grande was nearly one billion dollars and the number of employees totalled 32,000. Total sales were nearly \$800 million.

While the growth of the Gulf Coast chemical industry during the past decade has been spectacular, it has been largely confined to the mass production of chemical compounds and intermediates; in only a few categories—notably



fertilisers, insecticides and detergents—have these chemicals been processed to consumer products. An example of a newer phase of chemical development is the recently opened \$7 million plant of Texas City Chemicals Inc., the principal product of which is dicalcium phosphate—a valuable component for stock and poultry feed supplement and for fertiliser. The raw materials are phosphate rock (readily available from Florida by water transport) and sulphur, lime and salt, which are in abundant supply in the West Gulf Coast. An arrangement with the neighbouring Carbide and Carbon Chemicals Co. will help to reduce production costs.

Not only is the growth of the industry of the West Gulf Coast exemplified by the increase in capital investments and planned expansions, but also by the increase in the number of chemical compounds and intermediates which are being produced. In a report issued two years ago by the Houston Chamber of Commerce 106 organic chemicals were listed; last year there were 127 and this year's report lists 189. The firm basis of the organic chemical industry in the Houston area is shown by the fact that over 401,000 barrels of oil were produced daily in 1952—14% of Texas production and about 6½% of U.S. production. Production of marketable natural gas in 1951 was about 2,600 million cu. ft. daily, of which 855 million cu. ft. were returned to reservoirs and 1,745 million cu. ft. were used and marketed. There are 12 refineries in the area with a crude oil processing capacity of 885,500 barrels daily.

Investment in synthetic rubber facilities in the area is \$134 million. There are two butadiene, two styrene, and two copolymer plants which have a capacity to produce 112,500 tons a year of GR-S rubber. In addition, there is a butyl rubber plant with a capacity of 40,000 tons.

### Decontamination of radioactive water supplies

SUCCESSFUL decontamination of radioactive water with clay is reported by an American chemist, W. J. Lacy. His experiments follow tests which were originally made in 1951. In *Industrial and Engineering Chemistry* he claims that, in laboratory tests using ordinary clay found in the area around Oak Ridge, Tennessee, in some cases as much as 99.9% of the radioactivity was removed from tap water to which radioactive materials had been added.

There are two principal types of clay around Oak Ridge—montmorillonite and kaolinite. Mr. Lacy used montmorillonite. The water was purified simply by stirring from 1,000 to 4,000 parts of clay with 1 million parts of water for periods up to 1 and 1½ hr. and then filtering. The completeness of decontamination was measured with a Geiger counter both before and after treatment.

The water was artificially contaminated by adding the radioactive forms of such substances as zirconium, strontium, cerium, barium, iodine and mixed fission products obtained from the Oak Ridge National Laboratory. These materials were introduced in amounts to cover the calculated range of contamination immediately after a bomb blast near a large water supply. After contamination, the water showed activity ranging from about 60,000 to more than 360,000 counts a minute in each ounce. From 73.3 to nearly 100% of all radioactive contaminants except iodine were removed and up to 5% of the iodine was removed in these tests.

Mr. Lacy's data show that 1,000 parts of clay in 1 million parts of water are adequate and that most of the decontamination occurs during the first 15 min. He notes, however, that increased contact times were of value for

materials difficult to remove. The clay was most effective in removing radioactive cerium and strontium and moderately effective in removing the mixed fission products. It appeared to be more effective when the water was neutral or alkaline. It is thought that the substances are probably removed both by being trapped in the clay particles and by being exchanged for other substances in the clay.

Most surface waters contain some clay in suspension and it is probable that a certain amount of self-decontamination would take place if the waters were contaminated with radioactive materials. In addition, the water would come in contact with clay and soil particles in the bed or bottom of the stream or lake.

Treatment of the water by coagulation would remove much of the radioactivity by removing the contaminated clay particles and also by coagulation as such. The effectiveness of a coagulation process in regard to radioactivity removal could be increased by either a preliminary mixing with clay or the addition of clay directly to the water during the coagulation step along with the coagulating chemicals.

### Industrial development in Chile

PROJECTS which are being contemplated for Chile's chemical, mining and processing industries should provide opportunities for British plant suppliers. High on the list is a factory for manufacturing phosphate fertiliser from imported raw materials. The basic units would be a superphosphate plant with a capacity of 120,000 tons p.a., producing fertiliser of 25 to 26% of  $P_2O_5$ ; a triple superphosphate plant with a capacity of 12,000 tons of product with 45 to 46%  $P_2O_5$ ; a phosphate precipitate plant with a capacity of 15,000 tons p.a. of a product with 38 to 40%  $P_2O_5$ ; and a sulphuric acid plant. The total cost of the fertiliser factory would be about Ch.\$650 million (Ch.\$110 = U.S.\$1), of which Ch.\$230 million would be local investment.

The installation of a beet sugar plant with a capacity of 20,000 tons p.a. in the province of Llanquihue is also being considered, together with two plants of 10,000 tons in Cautin and Linares. The total investment for these plants will amount to about Ch.\$2,900 million. The amount to be spent on imported equipment is estimated at U.S.\$3 million.

As part of a comprehensive timber industry to be set up at Los Lagos, Valdivia Province, plants for carbonisation and the recovery of by-products (acetic acid and methanol) with a capacity for processing 50,000 tons p.a. of lumber will be required.

All the foregoing are projects in a fairly advanced stage, as are also an electrolytic copper refinery with an annual production of 25,000 tons p.a., and the restoration and reconditioning of the Chegres plant for the production of up to 15,000 tons of blister copper.

Longer-term projects include a plant to produce 8,000 tons p.a. of soda, 9,000 tons of soda-ash and 5,000 tons p.a. of nitric acid, from sodium nitrate. Another likely development is the construction of a 3,000 tons p.a. zinc refinery.

The organisation responsible for these projects is the Chilean Corporation for the Development of Production (C.O.R.F.O.), a Government-sponsored body set up in 1939. In some cases it is a direct importer of capital goods, while in others it assists private industry with loans, etc. Interested firms should get in touch with the Commercial Secretary at the British Embassy, Santiago, who will supply whatever further information may be available about particular projects.



# CHANGING CONCEPTS IN CHEMICAL ENGINEERING

By T. K. Ross, Ph.D., M.I.Chem.E. and D. C. Freshwater, B.Sc., A.M.I.Chem.E.

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*The authors suggest that the unit operations which have provided the foundation of chemical engineering for 50 years can now be advantageously examined for their content of four basic physical operations—handling, heating, subdividing, and mixing. They argue that regardless of its internal complexity any unit operation can be seen to comprise some or all of these four basics. This outlook is considered at length and its advantages in terms of better design and engineering are discussed.*

THE beginnings of chemical engineering as a technology may be traced to the era of Davis and Armstrong, when the idea of the unit operation was conceived. In this initial stroke, in which physical operations displaced chemical processes as the key to the study of chemical manufactures, the chemical engineer emerged as a separate species from the industrial chemist. Naturally, this emergence was not so sharp or so sweeping as it may be made to appear by uttering some simple date, such as 1880, when an attempt was made to form a Society of Chemical Engineers, or 1901, when Davis published his handbook. The process was prolonged and rather hesitant and it must be recorded that it practically suffered extinction, to be reborn in America.

Over something like 50 years this working philosophy has done Trojan service in providing the impetus for the development of chemical engineering as a scientific method. Fittingly, in a young profession, this philosophy never attained the rank of sacred dogma, and already it may be said that the unit operation has become obsolete; no longer able to advance the subject, it must pass.

The modern tendency<sup>1</sup> is to recognise the essential unity of all diffusional processes, and to identify all their methods and solutions in the pure light of the physics of the boundary state. This rarefied climate is not, however, without its dangers, for it breeds a tendency to rephrase the term chemical engineering, in which the pronunciation of 'engineering' becomes practically inaudible. The wholesale rejection of the unit operation can widen the gap between theory and practice, for some unit operations are implicit in every attempt to produce a piece of engineering equipment in which matter and energy are exchanged between contiguous phases.

It is this notion—of similarity between groups of operations—which gives the key to a new approach on rational lines. It is proposed to consider this new outlook in this article, to see how it differs from earlier views and to discuss its advantages.

## The four fundamental operations

The unit operations may be considered as consisting of mechanical procedures which are designed to allow some physical or chemical operation to take place. Many of these operations embody what are termed diffusional processes, in which matter and energy are transferred between phases having a common interface. There are other unit operations which are more mechanical in nature and in which material is separated without any phase boundary being passed. However, regardless of its internal complexity, any unit operation can be seen to comprise some or all of the following four essentials when translated into practice:<sup>2</sup>

- (1) It must be able to handle the material passing through the system. There must be adequate provision for the reacting material, be it solid, liquid or gas, to flow into and through the apparatus, and this holds whether the flow is continuous or batchwise.
- (2) It must be able to effect any heating or cooling of the material which may be necessary.
- (3) It must include provision for making the interfacial area between the reacting solids or fluids as large as is reasonably possible.
- (4) It must bring these freshly created surfaces into intimate and efficient contact so that the necessary heat and mass transfer may take place.

The basic provisions which a processing plant must provide in order that phase transformations may take place are summarised by its need to handle, heat, subdivide and mix and are evaluated for some typical unit operations in Fig. 1.

The field of unit operations involving mass transfer, such as distillation, absorption, extraction and so on, is so important industrially that it may be desirable to add a fifth essential to the above list, that of diffusional transfer of matter. Again it should be emphasised that this is fundamental to all such operations and the wide differences in the conventional methods of

solving problems in each operation arise largely as a matter of convenience in applying the data in a given case. However, the presence of diffusional transfer is not so much a basic as the *raison d'être* of a process, and it is with the physical implementation of this transfer that the four basics are concerned.

## Materials handling

Consider first of all materials handling. Many items of chemical plant, such as evaporators, columns, cooling towers, have conventional and recognisable forms simply because such forms are particularly well adapted to handle the flow of material through them. An appreciation of this helps in tackling a given design from this basic standpoint and may lead to a break with a traditional form. A classic example of such a break is the development of the fluidised catalyst technique.

The emphasis on ability to handle materials successfully leads, in the special cases encountered in chemical works, to equipment being designed primarily on a basis of resistance to corrosion rather than conventional fluid mechanical efficiency.

## Heat transfer

The three mechanisms of conduction, convection and radiation by which heat is transferred are familiar from a study of elementary physics, where, for the purposes of exposition, each method is treated separately. In practice, of course, all three mechanisms are in operation simultaneously and, although one may make approximations which neglect one or more of the less important methods in special cases, in general all must be considered.

One of the greatest advances in the study of heat transfer has been the application of the knowledge that heat transfer by convection is linked quantitatively with fluid motion. This has led to many specialised designs of heaters. However, as a contrast, it is possible to find examples in many chemical processes of older types of equipment persisting because, although they are less efficient as heat transfer apparatus, they

provide a better answer to the problem of material handling than do the newer designs.

### Subdivision of materials

The logical extension of fluid flow and heat transfer principles in all unit operations is familiar perhaps because it is so obvious. Less obvious is the similar application of general principles of subdivision to all kinds of operations.

Most of the unit operations are dependent upon contact area. Either energy or matter or both pass from one phase to another across a mutual interface. Hence the provision of this interface is a very important part of such unit operations. It is a matter of common experience that any simple chemical or physical process, such as reaction or solution, is increased when the interfacial area between the reactants is increased. Thus size reduction is important, not only in processing solids, but in treating gas with liquids or liquids with liquids.

The subject falls naturally into a consideration of size reduction of solids and of liquids. The underlying idea that size reduction involves the creation of fresh surface and hence the consumption of energy is common to both fields, although the practice of crushing and grinding and the formation of sprays on agitation of liquids is very different.

The rate at which this energy must be supplied is one of the main problems of the engineer dealing with this type of operation. The conditions, however, are rather complex and there is no real body of fundamental knowledge which can be applied. Recourse is usually had to a number of empirical rules based on practical experience with the type of material being handled.

### Mixing

This is very closely connected with subdivision and in the case of fluids it is practically impossible to separate the two operations. If production of a large interfacial surface area is important, then the bringing together of the dispersed and continuous phases is essential. Often an efficient mixer is acting in part as a size reduction apparatus simultaneously.

Mixing problems may be classified conveniently on the basis of the phases present; thus we have, in order of difficulty:

- (1) Gas with gas.
- (2) Liquid with liquid.
- (3) Solid with liquid.
- (4) Solid with solid.
- (5) Gas with liquid.
- (6) Gas with solid.
- (7) Gas with solid and liquid.

Although these are all basically similar, it is most instructive for our present purpose to consider case (5), the mixing of gases and liquid. This is fundamental to the important operations of distillation, absorption and humidification, but such

UNIT OPERATIONS	DRYING	EVAPORATION	CRYSTALLIZATION	HUMIDIFICATION	DISTILLATION	GAS ABSORPTION	SOLVENT EXTRACTION	LEACHING
BASICS								
MATERIALS HANDLING								
HEAT TRANSFER								
SUB DIVISION OR SURFACE CREATION								
AGITATION OR SURFACE UTILISATION								

Fig. 1. Breakdown of some common unit operations showing relative proportion of basics in each.

equipment is rarely considered from the standpoint of its action as a size reduction and mixing device.

Nevertheless, it is self-evident that fresh surface is created and the dispersed material brought into intimate contact with the continuous phase. In the usual design of such equipment, the bubble cap plate or packed column, the necessary energy is supplied by the pressure energy stored in the vapour or gas and its consumption as size reduction and mixing energy appears as part of the pressure drop<sup>3</sup> across the plate or packing. In some types of apparatus, such as gas washers, the mixing energy is supplied externally by a motor driving a stirrer or by a pump circulating liquor. Yet another method of energy input exists in the case of spray towers where the energy is stored in a liquid under pressure and released by its expansion through a nozzle.

This suggests a method of comparing the efficiencies of different types of mass transfer contacting equipment on the basis of energy consumption per theoretical stage. This may be made clear by a simple example. Consider a bubble cap plate

operating at atmospheric pressure with a pressure drop of 0.1 p.s.i. and Murphree efficiency of 50%.

Under these conditions the energy charge in the vapour is equivalent to  
 $5,180 \text{ ft. lb./lb. mole of vapour/plate}$   
 or  $10,360 \text{ ft. lb./lb. mole of vapour/theoretical plate}$ .

Compare this now with the operation of a multi-stage rotating-type gas washer handling 1 million cu. ft. of gas/hr. with a pressure drop of 1 in. W.G. The power required to drive the brushes is 5 h.p. and the equivalent number of theoretical stages is two.

The energy equivalent to the pressure drop is

$$2,160 \text{ ft. lb./lb. mole of gas.}$$

The energy equivalent to the h.p. of the brush motion is

$$3,600 \text{ ft. lb./lb. mole of gas.}$$

This gives a total of

$$5,760 \text{ ft. lb./lb. mole or } \frac{5,760}{2} =$$

$2,880 \text{ ft. lb./lb. mole gas/theoretical stage}$ . Even more provocative is a comparison on this basis between the performance of a

bubble cap plate operating at a pressure of a few atmospheres and the same plate operating under vacuum. This shows that under vacuum the plate requires about 10 times the proportion of available energy to achieve the same efficiency as at higher pressure<sup>4</sup> and suggests that by carrying this analysis further a more rational design may be obtained.

An important corollary of the idea of mass transfer equipment as mixing apparatus is that the energy consumption should be some simple function of the new surface created.<sup>3</sup> Thus it should be possible both to measure and predict the interfacial area for a given layout and so overcome one of the main problems in the design of such equipment.

### Diffusional processes

Diffusional transfer is common to a number of important unit operations, yet despite this common factor it is still not sufficiently emphasised that many seemingly diverse operations, such as crystallisation and distillation, drying and absorption, are closely related. This is probably due to the emphasis given to the method of solving problems in each operation. The conventional methods usually presented are widely different for each, yet because of the basic similarity between the different operations methods can be developed which apply with only small modifications to all of them. In the design of equipment involving diffusional processes there are two problems in addition to the four fundamentals discussed already. First, the provision of the required number of stages, since stepwise separation or its equivalent is generally assumed. Second, the provision

of adequate volume, depending on rate data for the particular mass transfer involved.

It is in solving the first of these problems that so many different techniques are encountered. However, all may be analysed by the calculus of finite differences and for many of them a common difference point type of construction may be used. For example, it is possible to carry out stage-wise calculations for leaching, fractional crystallisation, absorption and fractionation (involving three components) on a triangular diagram by a method usually reserved for solving problems in liquid extraction.

It is generally true that one type of graphical solution is more convenient in the solution of a certain unit operation, but it must be appreciated that the use of different techniques is purely arbitrary, and that the differences are superficial rather than fundamental.

In the final analysis the truth of the theory is the pragmatical test of the success or otherwise of practical applications to the design of the plant provided. It is instructive to trace the effect of the balance between the four basics upon the general trend of plant design (see Fig. 2).

### Plant design

A glance at plant catalogues or process descriptions in patents and other literature always impresses the reader with the great advance and change of design which has taken place in the equipment used for some unit operations compared with the almost total lack of change in others. The most fundamental change in design philosophy since the end of the last century has doubt-

less been the appreciation of the diffusional nature of the operations carried out in chemical processing plant. It is the growth of this idea which has changed the whole outlook of the chemical engineer and which has been responsible for the emergence of the 'theoretical plate, stage, or transfer unit' kind of approach to the problems of design.

Side by side with, and in a large part complementary to, this development there has also been the often unexpressed need to produce equipment which solves the handling, heating and phase contacting problems involved in the physical provision of a theoretical stage. This need finally to 'engineer' the abstract ideal of an equilibrium contact or stage into some practical approach to equilibrium results in the diversity of design prevalent amongst chemical plant.

Now the emphasis upon the fundamental items of design is often very unequal as between the recognised unit operations.

### Evaporation

Consider, for example, evaporating plant, where the main problem is the transfer and conservation of heat, whilst the handling task is comparatively simple. The history of evaporator design is therefore one marked by the stages at which engineers realised that the evaporative rate was dependent upon the shape and disposition of the heating surfaces, and upon the route of the heated liquor (see Fig. 3). The development of various typical designs was usually urged by the problems of a particular industry, and so those designs which solved the combined heating and handling problems of a particular application have tended to persist. Thus, it is not so much the case that newer machines have completely replaced earlier types, as that old and new exist side by side in those fields where they are most useful. The two great advances in this field—the multi-effect principle and that of vapour recompression—have accentuated rather than removed the need for continued development of design. It is noticeable how the appreciation of the underlying problem has led to a break from traditional form and appearance. The modern film evaporator, with its long narrow calandria, through which the liquor passes only once to move into the flash head and separator, is a logical but hardly recognisable descendant of the older vertical or horizontal machine with steam-heated tubes immersed in a large volume of boiling liquor.

### Drying

A different balance of basics is found in the design of drying equipment; here the dual requirements of heat transfer into, and diffusion of vapour out of, the drying mass are absolute. But, once these are provided by heated shelves or hot gas streams, the underlying practical problem of providing a drier is that associated with the handling of the stock. This may vary

BASIC	PLANT				
	PACKED COLUMN	BUBBLE CAP	SIEVE PLATES	SPECIAL DESIGNS	MECHANICAL ROTARY TYPES
HANDLE					
HEAT					
SUB-DIVIDE					
MIX					

Fig. 2. Breakdown of gas absorption equipment showing relative importance of basics in each type.



from a free-flowing grain to a sticky paste, and drier design must be varied accordingly. The tray or shelf type of machine solves the problem of the wet sticky mass in a fashion which, however, limits the area over which heat and mass transfer may take place, and, moreover, imposes a batch type of operation. On the other hand, the rotary drier makes the best possible use of interfacial contact, but, of course, is only applicable to free-flowing materials. Later developments include the through circulation machine, in which sticky material is preformed into pellets which are then formed into a bed on a moving perforated belt, through which hot gas is caused to flow. The handling, heating and contacting requirements are also attacked in a different way by devices using V.H.F. or infra-red radiant energy, which dispose of the heating problem as requiring contact between phases and leave the handling problem unrestricted. More recently still the fluidisation technique has been successfully applied to the drying of granular solids. This is a striking example of a means of bringing solid material into a free-flowing, transportable state, while using the fluidising gas as a medium for heat and mass transfer over the whole solid surface.

#### Diffusional operations

The so-called diffusional operations, such as gas absorption, distillation, solvent extraction, leaching and crystallisation, are all, by their very nature, firstly concerned with the problem of creating and using efficiently interfacial surface (or with subdividing and mixing). The problems of heat transfer and materials handling are subsidiary, but not negligible parts of the whole. Thus, the customary gas absorption tower—a vertical cylinder filled with inert bodies—is made in this form because it provides a ready means of (a) creating surface between a gas and a liquid, and (b) of handling the gas and liquid in a very simple manner, a matter of some importance when corrosive conditions entail the use of varied materials of construction. Research and investigation have been aimed at improving the former without complicating the latter, and so the development of ingenious packings and improved information on wetting and flooding characteristics go side by side in pursuit of this aim.

The fault of such a simple device is that it is a rather poor subdivider and mixer, and so is rather bulky when compared with other devices. So bubble caps and perforated plates were developed, in which more violent subdivision and agitation, combined with less haphazard directing of the gas and liquid, was obtained at the expense of simplicity.

#### Distillation

Very similar conditions apply in distillation, but the problems of handling and mass transfer are complicated by the considerable heat effects that must be taken into account. Thus, although apparatus

for gas absorption and distillation is particularly interchangeable, the associated heat transfer problems in practice cause a certain conventional rigidity in application.

#### Leaching and extraction

The problems of interface creation are not so predominant in these instances, as, for example, in the case of solvent extraction or solids leaching. Here a very real part of the function of a stage or cell is to create the interface across which matter transfer may take place, and when dealing

with solids or liquids or high surface tension the energy so consumed is considerable. Further, it is not enough to create the surface, for it must subsequently be used efficiently, so that the internal diffusion of solute may be accelerated.

On the one hand, adaptations from gas-liquid contactors, such as spray towers, or perforated and packed columns, have been made; also the principles of flow mixing or agitated vessels have been used. In either case the problems of creating and

(Concluded on page 237)

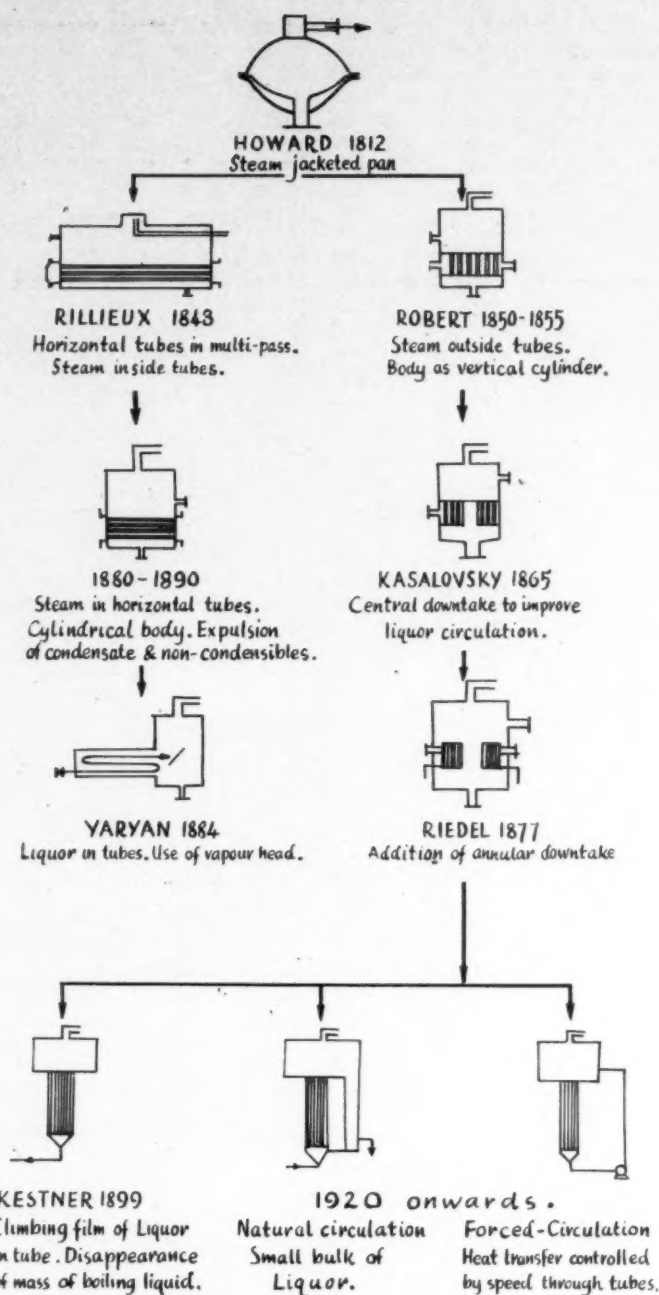


Fig. 3. Development of evaporator design showing influence of handling and heat transfer considerations.

# CRYSTALLISATION

**Crystal growth; fractional crystallisation; production of sodium sulphate, nitrogenous salts, potash, sugar, etc.; crystallising plant**

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## Crystal growth

**P**RACTICAL crystallising devices for use in laboratory crystallisation experiments are described by Kunze,<sup>32</sup> who has also discussed the possibility of applying the results to a given method on a production scale plant. This writer has investigated the speed of crystallisation and the inoculation rate of saturated solutions.

Shirazaki and Muroya<sup>38</sup> have proposed a method for increasing the rate of crystallisation and the size of crystals by the addition of small amounts of polymerised sodium phosphate. A further patent<sup>50</sup> gives many examples of crystallisation of inorganic substances with the addition of sodium phosphate or its polymer. Ammonium sulphate crystals obtained from solution under the same conditions were more than 10 times larger (0.4 to 0.6 mm.) when small amounts of sulphuric acid and sodium phosphate were added.

Hirano<sup>36</sup> has observed that crystal growth of several inorganic salts is accelerated under the influence of superhigh frequency waves of 20- to 30-cm. wavelengths. Lewin and Vance<sup>34</sup> have studied the influence of hydrogen ion concentration, solubility, rate of precipitation and relative supersaturation on the crystal growth of strontium sulphate. They describe a new technique for the batch crystallisation of strontium sulphate.

The experiment of Berg, Bunn and Humphreys-Owen on the concentration of the solute in the vicinity of a growing crystal has been repeated by Goldshtaub and Kern,<sup>18</sup> who found that in rapid growth the concentration gradient is greater at the crystal edges than above the face interiors. This fact explains the transport of solute to the crystal edges and the occurrence of dendritic growth. Bloch and Reiner<sup>8</sup> have investigated the solution of salt crystals. Solution occurs on horizontal and near horizontal faces; vertical and undercut faces are protected by a film of saturated salt solution, which adheres even against the force of gravity.

Seifert<sup>36</sup> has reviewed modification of the habit of growing crystals by impurities and has described the effect of glycerine on sodium chloride crystals.

The systems sodium chloride-strontium sulphate and sodium chloride-barium sul-

phate have been investigated by Bye and Holder.<sup>10</sup> Lamberger and Paris<sup>33</sup> have reported on the system calcium nitrate in ammonium nitrate-water. Wendrow and Kobe<sup>72</sup> have made a study of the system sodium oxide-phosphorus pentoxide-water. The data include the binary systems trisodium phosphate-water, disodium phosphate-water, and mono-sodium phosphate-water.

The crystallisation of salts of the type sodium sulphate hydrate,  $\text{Na}_4(\text{SO}_5 \cdot \text{H}_2\text{O})_x$ ,  $\text{H}_2\text{O}$ , and sodium solenite hydrate,  $\text{Na}_4(\text{SeO}_5 \cdot \text{H}_2\text{O})_x \cdot \text{H}_2\text{O}$ , from aqueous solutions of sodium sulphate, sodium solenite, and sodium hydroxide has been investigated by Windmaisser and Stockl.<sup>75</sup>

## Fractional crystallisation

The ability of urea to form crystalline complexes with many types of straight chain aliphatic molecules offers a new method for the purification of suitable substances. Truter<sup>65</sup> describes the structure and properties of these urea complexes and discusses the fundamental principles governing the separation of the mixtures. The author also gives a brief review of the applications of the process.

An apparatus for the purification of compounds by fractional crystallisation is described.<sup>16</sup> An example is given where purified cyclohexane is obtained from a mixture of 80% commercial cyclohexane and 20% other hydrocarbons. Separation of benzene-hexane and *m*-xylene-*p*-xylene is described by Graham,<sup>20</sup> who has patented a rotary crystalliser for the continuous separation of binary mixtures of organic compounds. A multi-stage crystallisation process for the separation of mixtures of compounds is described in a patent by Hachmuth.<sup>24</sup>

A method of separating one or more constituents of a mixture of liquids having different points of crystallisation is patented by Rütgerswerke.<sup>55</sup> It is particularly applicable to the various fractions of coal-tar.

The continuous separation of organic compounds having a wide range of melting points is patented by Carney.<sup>11</sup> The system is used for the separation of palmitic acid from palm oil and the separation and purification of petroleum hydrocarbons.

## Sodium sulphate

The production of anhydrous sodium sulphate from natural brines is described by Weisman and Anderson.<sup>71</sup> A more general description, together with a pictured flowsheet, has also been published.<sup>13</sup> The natural brine is concentrated by solar evaporation to 10%  $\text{Na}_2\text{SO}_4$ , which is then recovered as the decahydrate by cooling to 15°F. The hydrated crystals are melted and the water of crystallisation removed by submerged combustion.

The recovery of anhydrous sodium sulphate from viscose rayon spin bath liquor is described in a patent by Malm.<sup>38</sup> This liquor may contain 10 to 34% dissolved salts. A feature of the above process is that during evaporation the  $\text{Na}_2\text{SO}_4$  ratio is maintained at at least 2 : 1 and the major part of the anhydrous salt is precipitated at a temperature of 32 to 60°C. The balance of the sulphate is recovered as precipitated sodium bisulphate by the addition of concentrated sulphuric acid.

Wiseman<sup>76</sup> has patented an evaporator for the continuous concentration and evaporation of solutions of salts having inverted solubility curves. A further patent<sup>77</sup> refers specifically to the concentration of sodium sulphate solutions. The invention is based upon the principles of bringing the solution into contact with a relatively hot dry gas under such conditions that the gas is cooled to the desired temperature of the effluent liquid and on maintaining the hot gas chamber surfaces wet with the liquor to prevent the precipitation of the salt. The concentrated liquor removed from the evaporator is saturated in respect of the salt and contains some suspended salt crystals. Further salt is recovered by adding make-up hydrated salt. After separation of the salt crystals the mother liquor is returned to the evaporator. Fuel efficiencies in excess of 95% are claimed.

An apparatus designed especially for the crystallisation of hydrated sodium sulphate is patented by Paoli.<sup>47</sup>

## Nitrogenous salts

Apparatus for the determination of the principal constituent in ammonium sulphate or similar salts, based on the determination of the electrical conductivity of

salt granules placed between salt granules, is covered by a Japanese patent.<sup>62</sup>

Robinson<sup>52</sup> has described a process for making exceptionally small ammonium sulphate crystals by the evaporation of ammonium sulphate by submerged combustion. Crystal size is controlled by the additives. It is claimed that the product does not cake and that it has a high bulk density (75 lb./cu. ft.). The same inventor also describes<sup>54</sup> a treatment of the calcium sulphate slurry, used in the gypsum process, which increases the yield of ammonium sulphate.

Olson<sup>45</sup> has patented a process for the production of ammonium sulphate from residues obtained in the cracking of certain petroleum fractions and sludges. Hori has a patent<sup>47</sup> for the production of ammonium sulphate by the direct reaction between ammonia gas and sulphuric acid, and another<sup>28</sup> for the production of the salt from the reaction between ammonium thiosulphate, gaseous ammonia and oxygen. Improvements to the well-known Otto saturator are reported.<sup>46</sup> Ogilvie<sup>44</sup> applies the principles of submerged combustion to the concentration of dilute ammonium sulphate, such as is obtained from the gypsum process.

Two processes are described<sup>40</sup> for the manufacture of ammonium sulphate from ferrous sulphate which is recovered as a by-product in the titanium pigment industry. A further process by Thomsen<sup>64</sup> recovers ammonium sulphate from ores containing iron, zinc and copper sulphides.

Shearon and Dunwoody<sup>57</sup> describe the graining process, the *Krystal* process and the 'prilling' process for the production of ammonium nitrate. Equipment for the production of ammonium nitrate is also described.

Greer and Lawrence<sup>22</sup> claim more efficient production of ammonium nitrate by the equipping of the reactor exit stack with bubble caps and water spray located above. Ammonium nitrate production is also covered by a Belgian patent.<sup>6</sup>

Several patents have been taken out for the treatment of ammonium nitrate to prevent caking in storage. One by Goodale<sup>19</sup> covers the coating of ammonium nitrate particles with 0.1 to 0.5 weight per cent. of 2,2-dinitropropane combined with a non-volatile liquid. Robinson<sup>53</sup> describes the coating of ammonium nitrate with finely divided calcium carbonate in a fluidised bed of the mixed materials held in suspension by gaseous nitrogen. Opposite electrostatic charges are imposed upon the two materials during the coating procedure. The rate of calcium carbonate deposition is controlled by the amount of electrostatic charge on the particles, and the rate of flow of nitrogen through the suspension. Whetstone<sup>74</sup> describes the surface treatment of ammonium nitrate crystals with a polysulphonated derivative of a triamino-substituted triarylmethane dye and others.

Processes for the production of ammonium nitrite are patented.<sup>2, 29</sup> Further

patents<sup>66, 67</sup> cover the production of ammonium chloride. The recovery of both ammonium chloride and sodium bicarbonate from a mixed solution of ammonium chloride and ammonium carbonate is described by Oda and others.<sup>43</sup>

Herrmann<sup>25</sup> describes a process for the continuous production of ammonium chloride crystals of uniform size containing 0.2% lead chloride.

Potassium nitrate and sodium nitrate are produced by treating wyomingite with sodium nitrite and water in an autoclave at 200°C. and 200 to 50 p.s.i.g.<sup>48</sup> Potassium nitrate and ammonium chloride are obtained from a solution of ammonium nitrate and potassium chloride.<sup>37</sup>

#### Miscellaneous inorganic salts

Thomsen<sup>63</sup> describes the processing of an ore containing both copper and sulphur to produce copper sulphate. The milled and concentrated ore is roasted. The gases from the roaster are scrubbed with water and the resulting sulphuric acid used to leach the calcines from the roaster. The leached liquor is evaporated, crystallised and copper sulphate pentahydrate crystals separated and dried.

Adamski and Frankle<sup>1</sup> have described a crystallisation process for obtaining sodium hydroxide, containing only small amount of sodium chloride from diaphragm cell liquor.

Calcium sulphate as a raw material is reviewed by Akerman.<sup>4</sup> The addition of organic substances to improve the gypsum crystals by-produced in the ammonia-soda process is described,<sup>35</sup> as is also the production of gypsum from calcium chloride waste liquors.<sup>39</sup>

About 1,000 cu. m. of sea water are necessary to produce 450 kg. of potash. Test plants for the recovery of potash from sea water were started in 1950. A pilot plant having a capacity of 1,500 tonnes/annum is being put into commission this summer. The process is patented by A/S Norduco.<sup>42</sup> Sea water is treated with a solid highly nitrated secondary aromatic amine and a base. A slightly soluble potassium salt of the amine is precipitated. The precipitate is separated and acidified. The potassium salt of the acid goes into solution and the amine is precipitated and recovered for reuse.

Pike<sup>49</sup> describes the recovery of sodium sesquicarbonate crystals from crude trona. Vahl<sup>68</sup> has patented a process for the crystallisation of sodium carbonate.

The recovery of sodium chloride and potassium chloride from sea water by treatment with calcium chloride followed by fractional crystallisation is patented.<sup>30</sup>

The recovery and purification of uranium salts by crystallisation is described in a patent by Burrage and Mooney.<sup>9</sup>

The refining of potash in France from sylvanite has been reviewed.<sup>14</sup> The process is based upon simple solubility relationships. Vacuum cooling has been introduced on a large scale and it is claimed that this

method of crystallisation is rapid, makes possible the recovery of the heat of crystallisation and avoids caking of cooling surfaces.

The refining of salt by quadruple effect evaporation is also described.<sup>50</sup>

#### Sugar

Storms<sup>61</sup> discusses the concentration, seeding and crystallisation of sugar solutions, the concentration of which are measured by electrical resistance. Bermuda<sup>7</sup> has discussed the importance of controlling the final crystallisation in sugar manufacture and the theory of de-sugaring the mother liquor. The author has given examples of the calculations which have been derived and applied on curves. Gillett<sup>17</sup> proposes an improved method of full seeding and claims that the shock seeding method is not consistent and reliable largely because of changes in the non-sugars present. The crystallisation of sucrose is described by Nichik<sup>41</sup> and a description of the control of crystallisation in a low-grade massecuite is given by Silin.<sup>60</sup>

Webre<sup>70</sup> discusses the significance and control of sugar crystal formation and the objectionable features of conglomerates, fines and twins.

#### Crystallising apparatus and plant

A crystalliser for sylvanite has been patented by Douglass.<sup>15</sup> Gray<sup>21</sup> has a patent for the manufacture of crystals by recycling a portion of the magma to the barometric leg connecting a vacuum evaporator with a crystalliser; the production of ammonium sulphate is described.

Warner and Foord<sup>89</sup> patented an apparatus for growing large-size crystals from supersaturated solutions. Marks<sup>38</sup> describes a continuous apparatus for growing large crystals of iodocinchonidine sulphate  $\alpha$  or iodiquinine sulphate from saturated solutions.

An apparatus for the continuous production of synthetic crystals from an aqueous medium is described by Chaudoyé and Fourdeaux.<sup>12</sup> A patent for a crystallisation vessel has been taken out by Airaku and Ono.<sup>3</sup>

Algemene Kunstzijde<sup>5</sup> have patented a method of removing crusts from the cooling elements of a crystalliser by means of a jet of air or gas at a temperature less than the melting point of the crystals. The gas blown from a nozzle at a pressure of 4 to 6 atm. is caused to impinge upon the crusts. The method is claimed to be particularly suitable for salts containing water of crystallisation.

A sugar crystalliser especially adaptable to the development of crystals in massecuite is patented by Kopke.<sup>31</sup> Another sugar crystalliser is patented by Rodriguez.<sup>51</sup>

#### General

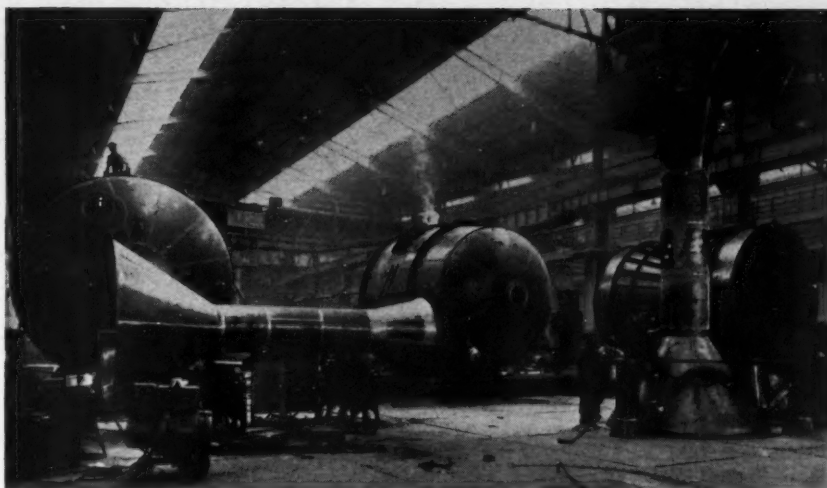
A review of crystallisation covering the subjects of additives affecting crystallisation, crystallisation equilibria, industrial crystallisation, practice, etc., and giving 82



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## Changing Concepts in Chemical Engineering

(Concluded from page 234)

using surface and the physical transportation of the resultant mixture tend to exert control over the lines along which equipment develops. Attempts to break this constraint have resulted in column-type machines employing agitation, vibrations or centrifugal effects.

\* \* \*

In conclusion, let it be said that there is no particular novelty in these notions; rather are they that incoherent part of design which must go hand in hand with improvements in calculating stagewise processes, which are based on the assumption of the theoretical contact between phases attaining equilibrium. But an appreciation of the basics of handling, heating, subdivision and agitation allows us to discern why the apparatus of particular unit operations takes a certain form.

Likewise the inspection of conventional apparatus designs for their content of these basics encourages audacity in new design, for it is all too easy to inherit a form of plant which was originally developed to solve one or the other basic problem into a process where this requirement is modified or totally absent.

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# FUEL CELLS

## 2. Low Temperature Cells, Future Developments

By A. M. Adams, M.A., A.Inst.P.

(British Electricity Research Laboratories, Leatherhead, Surrey)

*In the first part of his article, which appeared in the July issue, Mr. Adams stated the principles of operation of fuel cells and described early types and high-temperature cells. In this concluding part he deals with the very important low-temperature fuel cells which involve either the oxidation of hydrogen or redox processes. He concludes with a forecast of future developments and predicts that the chemical industry might be the first to use current generated from fuel cells owing to its particular suitability for electrochemical processes.*

THERE appears to be little possibility of devising any direct carbon/oxygen cell to operate below 250°C. Several claims to have accomplished this have been made, but on investigation the cells concerned have usually been found to be oxygen concentration cells. The only practicable solution appears to be to reduce a suitable compound by a preliminary reaction outside the cell, so obtaining a more reactive substance for electrochemical oxidation. The preliminary reduction reaction must be selected with care to prevent unnecessary energy losses and should preferably be capable of being carried out at low temperatures. If, for instance, a high-temperature gasification process is involved, heat losses will occur even with efficient heat-exchange arrangements. The sluggish electrochemical behaviour of oxygen at low temperatures also leads to difficulties and it has been proposed to carry out preliminary reactions with the oxygen also, to produce a more reactive substance such as a halogen. Here again the possibility of energy losses must be carefully examined.

A wide variety of reaction has been suggested as the basis of low-temperature fuel cells, but only those involving either the oxidation of hydrogen or redox processes appear to have any prospect of practical application and so only these types of cell are considered below.

### Hydrogen cells

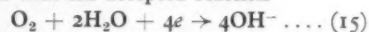
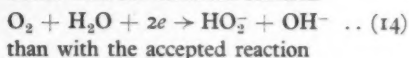
The hydrogen cell devised by Mond and Langer<sup>22</sup> has already been mentioned and its limitations discussed. Considerably later (Schmid, 1923,<sup>31</sup> 1924<sup>32</sup>), electrodes were introduced in which the gases were allowed to diffuse outwards through a porous material to the electrode/electrolyte interface; these enabled higher current densities, up to 20 ma./sq.cm. (18.6 amp./sq.ft.), to be attained without excessive polarisation. The next significant advance was reported from the Soviet Union (Davtyan, 1947):<sup>27</sup> the platinum or platinised carbon electrodes were replaced by active carbon containing 10% of finely divided silver or nickel and were prevented

from being wetted by a thin layer of wax on the surface in contact with the electrolyte, which was a 35% solution of potassium hydroxide. The construction of this cell is shown in Fig. 4; the two electrodes are clamped on either side of an ebonite ring containing the electrolyte, the back of the air electrode being exposed to the atmosphere, while the hydrogen electrode is enclosed at the rear to enable the fuel gas to be circulated over it. Silver-impregnated carbon was chosen for the hydrogen electrode and the nickel-impregnated carbon for the air electrode, after a lengthy series of experiments with various metals and metal-carbon combinations. The method of preparing the electrodes involved impregnation of the carbon with the nitrate of the metal, decomposition by heating, followed by treatment with sodium or potassium hydroxide solution and reduction under hydrogen; mention is also made of the addition of promoters such as the oxides of cerium, thorium and aluminium.

With this arrangement, Davtyan (1947)<sup>27</sup> claimed that a voltage of 0.68 v. was obtainable at a current density of 23 ma./

sq.cm. (21.4 amp./sq.ft.), the open-circuit voltage being 1.12 v. instead of a theoretical e.m.f. of 1.23 v. at 25°C. (Fig. 1, see Part I of article). By especial care in the preparation of the electrodes, voltages of 0.75 to 0.80 v. were obtainable at current densities of 25 to 35 ma./sq.cm. (23 to 32.5 amp./sq.ft.). No measurements of the overall energy efficiency of the cell are given or of the effects of prolonged operation; it is mentioned that the gases used must be free of carbon monoxide and dioxide, both of which combine with the electrolyte, producing formate and carbonate, respectively.

Current densities as high as 30 ma./sq.cm. (28 amp./sq.ft.) were also obtained by Kordes and Marko (1951)<sup>33</sup> using similar types of oxygen electrode, but they found that, as reported by Berl (1943),<sup>34</sup> the electrode potential normally agreed better with the electrode reaction



The e.m.f. of a hydrogen-oxygen cell operating on reaction (14) would be only

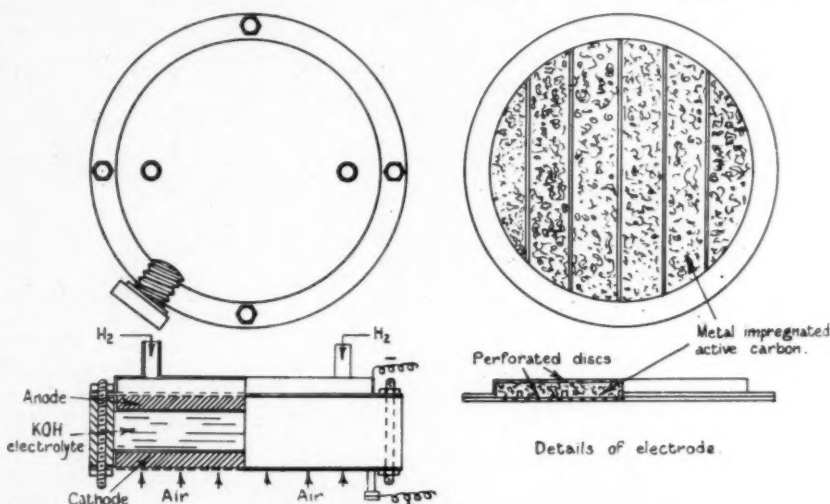


Fig. 4. Low-temperature hydrogen cell (Davtyan, 1947).

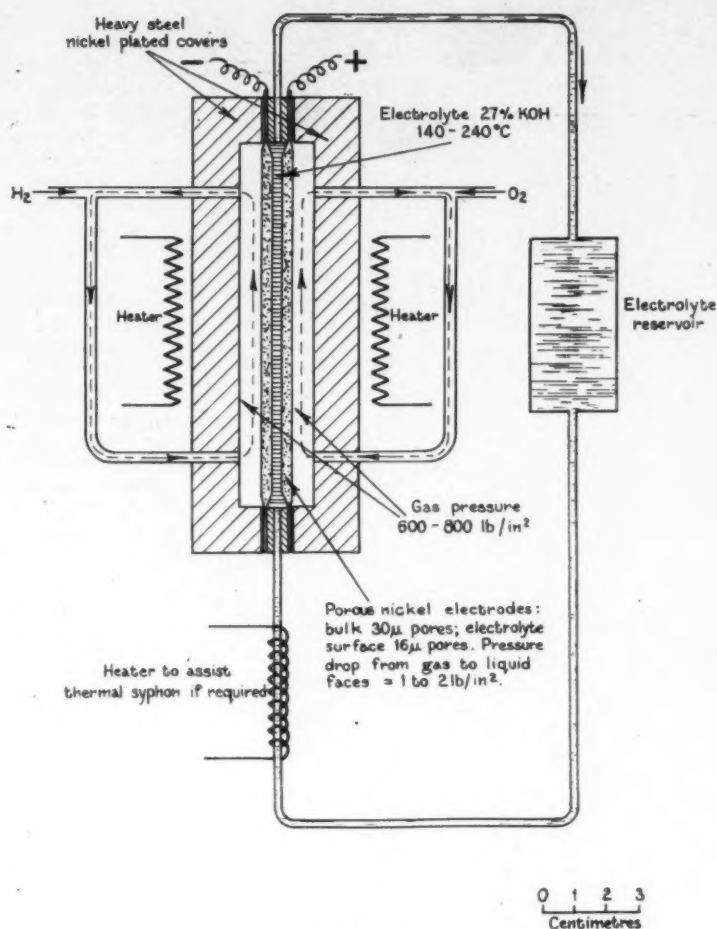


Fig. 5. Bacon high-pressure  $H_2$ - $O_2$  cell.

(Diagram reprinted from a paper by A. M. Adams on 'Recent Developments in Fuel Cells,' *Journal of The Institute of Fuel*, 1954, Vol. 27 (162), 369)

0.87 v. instead of 1.23 v. Recent measurements (Adams, 1954)<sup>35</sup> on cells of this type have also suggested that reaction (14) was predominant. The e.m.f. was 0.73 v. and difficulty was experienced in preventing the electrodes being wetted by the electrolyte.

Greatly superior results to those mentioned have been described (Bacon, 1952,<sup>36</sup> 1954,<sup>37</sup> Watson, 1952,<sup>38</sup> 1954<sup>39</sup>) in connection with a hydrogen-oxygen cell employing porous nickel electrodes and an electrolyte of 27% potassium hydroxide at 200 to 240°C.; the cell operates under a pressure of 400 to 800 lb. sq.in. and is shown diagrammatically in Fig. 5. The electrolyte is circulated through a space, only 2 mm. wide between the two circular electrodes, whilst the hydrogen and oxygen are supplied under pressure to the rear of their respective electrodes and tend to circulate over the exposed surfaces owing to a thermal syphon effect. The cell is enclosed in heavy steel covers. The electrodes are formed from nickel powder by sintering and are composite, the bulk of each electrode having pores of about 30 microns, whilst the surface layer in contact with the electrolyte has a thin layer of material of

about half this pore-size. In this manner and, by maintaining a small pressure differential of 1 to 2 lb. sq.in. across each electrode, just insufficient to expel the electrolyte from the fine pores, it is possible to dispense with any water-proofing process, while providing an electrode of large effective surface area. The interior of the 30-micron pores provides a large surface for adsorption of the gas and that of the fine pores similarly permits a large contact area between the electrode and thin films of electrolyte, in which diffusion processes can occur easily. An electrolyte reservoir and means for withdrawing the water formed, by evaporation from the

Table I. Voltage Output and Efficiency of Bacon  $H_2$ - $O_2$  Cell

(Data from Bacon, 1954)<sup>37</sup>

Current density		Voltage V	Voltage efficiency %
ma./sq.cm.	amp./sq.ft.		
0	0	1.05	90
162	1.51	0.9	77
413	3.84	0.8	68
720	6.70	0.7	60
1,076	1,000	0.6	51

rear of the hydrogen electrode and subsequent condensation, are also provided.

With this form of cell, which was evolved after many years of experiment, the results shown in Table I have been obtained at 240°C. and 800 lb./sq.in., under which conditions the theoretical e.m.f. is 1.17 v.

Under these conditions, the oxygen electrode showed considerable deterioration after only a few hours' run at first, but improved electrodes have now been developed and, at slightly reduced temperatures, at least one run of several hundred hours has been carried out. In view of the high power output per unit volume represented by the above figures, assuming the total thickness of each cell in a battery would be about  $\frac{1}{2}$  in., it is possible to envisage further development and commercial application in certain fields, such as to electric traction. At present electrolytic hydrogen, compressed into cylinders, is sold at about 50s. per 1,000 cu.ft., which is equivalent to a fuel cost of 7½ d. per kwh. A considerable proportion of this cost must be attributable to distribution expenses, since the electrolytic process efficiency is of the order of 50%, although energy is required for compressing the gas. If a satisfactory high-pressure electrolyser could be developed, preferably working at high temperatures, so that the overvoltage required was reduced, the possibility of economic application of the Bacon cell would be much improved; rail traction appears to be the most promising field initially and since the electrolyzers could be operated during off-peak periods, such a scheme would improve the load factor of an electric railway system and might eventually produce substantial economies in the coal requirements of the railways. The possibility of storing energy also might be of economic value in connection with electrochemical processes, for which the low voltage direct current produced by fuel cells is inherently suitable and, less probably, to improve the load factor of the public electricity supply system.

For bulk generation of electricity, cells of this type would use hydrogen produced by chemical processes. The cost of this would depend largely on the purity required and at present no information is available on this aspect. Even at 75% efficiency, it is doubtful whether any hydrogen cell could compete with conventional steam power stations, the average fuel cost of which is below 0.4 d./kwh. (British Electricity Authority, 1953).<sup>40</sup>

Hydrogen-chlorine cells have been proposed (Förster, 1923;<sup>41</sup> Schmid, 1924;<sup>42</sup> Davtyan, 1947<sup>27</sup>) and it seems probable that such cells could be constructed to give current densities of at least 20 ma./sq.cm. (18.6 amp./sq.ft.) without excessive polarization. It is doubtful whether such cells would be economic, however, because of the cost of preparing chlorine by means of atmospheric oxygen; the cheapest



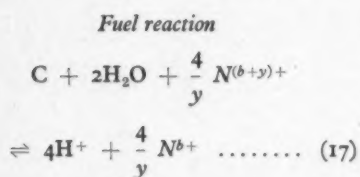
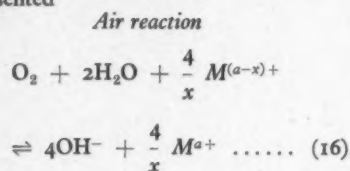
method of preparing chlorine industrially is by electrolysis. Hydrogen-chlorine cells might, however, be of value in connection with electrolytic sodium extraction plants to provide part of the energy requirements.

### Redox cells

Under suitable conditions it is possible to obtain reasonably rapid reaction rates between carbon and other substances at low temperatures; one group of these reactions between carbon and certain metallic ions forms the basis of the 'redox' fuel cells. Moreover, similar reactions can be carried out with air, so avoiding some of the difficulties experienced in obtaining satisfactory ionisation of oxygen.

Redox reactions depend on the stable existence of ions of the same chemical element or group carrying two or more different charges (e.g.  $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ ;  $\text{Cu}_2^{2+}$ ,  $\text{Cu}^{2+}$ ) and the possibility of varying these charges by oxidation and reduction reactions taking place outside the cell itself. The current generating reaction within the cell can then be one that occurs rapidly and with small energy losses. The conditions under which the oxidation and reduction reactions are carried out with air and the fuel can be independently controlled to obtain the maximum reaction rates. For instance, the temperature and pressure may be raised if necessary, and the fuel can be finely ground to present the maximum surface for reaction.

Representing the cation in contact with the air by the symbol  $M^{a+}$  in its higher state of oxidation and the cation in contact with the fuel by the symbol  $N^{b+}$  in its reduced state, the reactions with the oxygen of the air and with the fuel can be represented



where  $x$  and  $y$  represent the number of electrons transferred per ion and the equilibrium in both reactions would be well over to the right. If the equilibrium mixtures of solutions resulting from reactions (16) and (17) are then placed in a cell containing two inert electrodes, without inter-diffusion of the solutions occurring (e.g. by the use of a semi-permeable membrane between the two electrodes), a difference of potential will in general be set up. Representing the conditions in the cell as follows:

Inert Positive Electrode			
$M^{a+}$	.	.	$c_1$
$M^{(a-x)+}$	.	.	$c_2$
<hr/>			
$N^{b+}$	.	.	$c_3$
$N^{(b+y)+}$	.	.	$c_4$

where  $c_1 \gg c_2$  and  $c_3 \gg c_4$ , the potential difference  $E$  between the two electrodes will be given by

$$E = E_o^a - E_o^f + \frac{RT}{Fx} \ln \left( \frac{c_1}{c_2} \right) - \frac{RT}{Fy} \ln \left( \frac{c_4}{c_3} \right) \dots\dots\dots (18)$$

where  $R$ ,  $T$  and  $F$  have their usual significance and  $E_o^a$  and  $E_o^f$  are the redox potentials in the standard states of the solutions used in the air and fuel reactions, respectively.

In a simple form of redox cell, both electrode solutions might consist of ferrous and ferric solutions:

→ Air →			
Inert Positive Electrode			
$\text{Fe}^{3+}$	.	.	$c_1 \leftarrow$
$\leftarrow \text{Fe}^{2+}$	.	.	$c_2$
<hr/>			
$\rightarrow \text{Fe}^{2+}$	.	.	$c_3$
$\text{Fe}^{3+}$	.	.	$c_4 \rightarrow$
Inert Negative Electrode			
← Fuel ←			

For this system, the value of  $E$  according to equation (18) is unlikely to exceed 0.25 v.

On connecting the two electrodes through an external circuit, electrons would flow from the negative electrode to the positive electrode until the ratio of ferrous to ferric ions in both equilibria mixtures was the same, when the redox potentials would be equal and the e.m.f. of the cell would be zero. If, however, the electrode solutions were circulated through reaction vessels in which reactions (16) and (17) could take place continuously, the difference of potential between the two electrodes would be maintained in spite of appreciable current flowing in the external circuit. The voltage obtainable in practice would be less than that indicated by equation (18), owing to concentration gradients in the solutions near the electrodes and energy losses associated with the electrode processes, the ionic reactions and the migration of ions through the solutions. It seems probable that all these losses could be reduced to reasonable proportions by suitable design of the cells. On the other hand, the e.m.f. of 0.25 v. mentioned for a ferrous/ferric system represents less than 25% of that theoretically obtainable from the  $\text{C} \rightarrow \text{CO}_2$  reaction and it is therefore necessary to find a system yielding higher redox potentials. There is a wide choice of possible redox reactions, and at least in theory, a redox fuel reaction could be combined with another type of oxygen electrode such as the Davtayan or Bacon

types described above. In practice, difficulties might be experienced in such a combination. The choice of redox reaction is also limited by the conflicting requirements of a high e.m.f. for the cell and the necessity of choosing for reaction (17) a system in which the reduction of the cation from the higher to the lower valency state is capable of being carried out by means of the fuel. The rate of reaction will be accelerated by the choice of a reactive form of carbon; for instance, coal is more reactive than coke, but its oxidation products at low temperatures may include complex organic compounds that cannot easily be oxidised through to  $\text{CO}_2$ . It is believed, however, as a result of experiments at King's College, London (Posner and Bingham, 1952),<sup>42</sup> that reduction of  $\text{FeCl}_3$ ,  $\text{CuCl}_2$  and some mercury salts, with complete oxidation of the carbon to  $\text{CO}_2$ , is possible at temperatures between 160 and 190°C. under pressure. Moreover, effective catalysts have been found for the oxygen reaction. As yet, these experiments have been carried out on a small scale, and the future of redox fuel cells is at present somewhat speculative.

### Future developments

It is probably correct to say that no type of fuel cell has yet emerged from the research laboratory as a practicable means of generating electricity even on a small scale. On the other hand, three distinct stages of evolution can be seen in the various types of cell described above.

The high-pressure hydrogen-oxygen cell is in the most advanced state, although a number of problems remain to be solved; at the time of writing, the most serious of these, the deterioration of the oxygen electrode, appears to be capable of solution. Unless new methods of producing pure hydrogen from coal can be discovered or the cell is found to be capable of operation on impure gases, the hydrogen-oxygen cell is likely to be restricted to a limited range of applications not involving large-scale generation, although possibly including energy storage.

Research on high-temperature gas cells is less advanced and, while on thermodynamic grounds there appears to be no reason to doubt their possibilities, there are formidable practical difficulties to be overcome, particularly in respect of the stability of the electrolyte, whether the most suitable form of this proves to be solid, molten or some compromise between these, such as a porous ceramic impregnated with molten salt. There is also need for much more detailed research on the mechanism of the electrode and electrolyte processes in high-temperature cells than has yet been attempted. This aspect is not being neglected, however, and the application of modern knowledge of the structure of matter may have an important bearing on future progress. The economics of gasification processes also have a vital

(Concluded on page 246)

# SYNTHETIC FATS, SOAPS AND ALLIED PRODUCTS

## 2. Base Materials and Conversion Processes

By John Seaman

*In his first article in the June issue, Mr. Seaman discussed the feasibility of converting comparatively low-grade petroleum waxes obtained as refinery by-products into a range of higher grade products currently based upon glyceride oils and fats. Here he describes the nature of the base materials in more detail and considers the processes by which they can be converted into fatty acids for soap manufacture and edible fats. In his final article he will consider the economics of the schemes put forward.*

**B**EFORE dealing with processes for the conversion of petroleum and other waxes to the finished products outlined in Part I it is necessary to have a clear understanding of the nature of the base materials. It must also be established that adequate quantities are and will continue to be available at economic prices.

Practically all petroleum crudes contain some wax and the Middle East oils used in European refineries have wax contents up to about 30%. These waxes, of course, are largely long straight chain hydrocarbons and have not had any wide application in that form. In refinery operations designed for maximum output of fuels and lubricants for internal combustion engines the high molecular weight constituents of the feedstocks have been broken down by cracking to the fullest extent consistent with processing economics and market needs. Not only the waxes, but such lighter fractions as gas oil have been broken down to produce as much petrol as possible.

Since the demand for fuels and lubricants for internal combustion engines is likely to dominate the market for many years, it can safely be assumed that refinery processing schemes will not change fundamentally and that waxes will continue to be essentially by-products in relation thereto. The significance of this for the present purpose is that it ensures that there will be little change in the quantities and properties of available base materials. The main classifications are:

Paraffin wax	..	C <sub>18</sub> to C <sub>36</sub>	—m.p. 120 to 140°F.
Motor oil wax	..	C <sub>24</sub> to C <sub>36</sub>	.. 145 to 170°F.
Residual wax	..	C <sub>24</sub> to C <sub>36</sub>	.. 145 to 175°F.
Tank bottom wax	..	C <sub>18</sub> to C <sub>36</sub>	.. 180 to 200°F.

The important classifications in the present application are the first two. They are both obtained from distillates, i.e. wax and lube oil distillates, and can, therefore, be regarded as refined substances. The only major differences between these classifications of wax are in melting point and crystal structure, the latter being micro-crystalline.

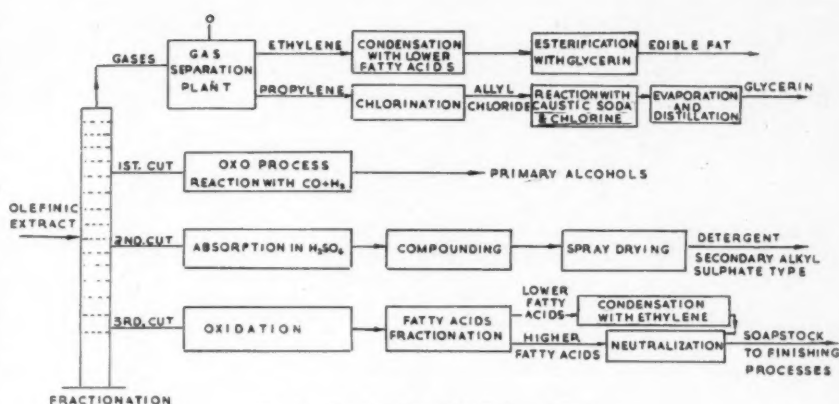


Fig. 1. Treatment of olefinic extract.

At this stage cost considerations begin to assume importance and the example is useful in indicating the conflict between technological and economic considerations. Whilst the waxes from the wax distillates are best for oxidation to fatty acids, it is the lube oil distillates which are most likely to be used initially. The reason for this is that the removal of wax from lube oils is incidental to the production of high-grade lubricants of low pour point, whilst in the other case it would normally only be carried out specifically to recover the wax, e.g. for cracking for the manufacture of the detergent bases, secondary alkyl sulphates and alkyl aryl sulphonates. It is important here to stress that the cost of separating waxes from wax distillates is not at all prohibitive, but it is an extra item compared with lube oil waxes. Furthermore, there is already quite a substantial market for crystalline waxes in solid form, whilst the micro-crystalline variety have, as yet, not been in much demand.

### Outline of process

The micro-crystalline waxes from lube distillates are quite suitable as raw material for the range of processes under consideration. For simplicity, let it be assumed that

the process starts with the dewaxing stage of the lube oil production and that the ketone-benzol method is used. In this the waxy oil, mixed with the correct quantity of methyl ethyl ketone and benzol, is passed through double pipe heat exchangers and refrigerated chillers, thereby precipitating the wax. For substantially complete separation of waxes from oil continuous drum-type vacuum filters are generally used. This is the stage at which modifications need to be introduced into present procedures owing to the fact that extracted waxes are not to be brought to marketable state at this point.

Thus, instead of passing the mixture of neutral oil, solvent and wax to the rotary filters, a comparatively crude separation is first carried out by passing the mix through a special type of strainer, to be described later. Issuing from this are practically dewaxed oil plus solvent and oily wax plus solvent. The former component reverts to normal lubricant manufacturing procedure, i.e. rotary vacuum filtration, with the advantage that appreciably less capacity is required appropriate to the much reduced wax content of the oil.

Solvent is stripped from the oily wax component and returned for re-use and

the bulk of neutral oil is removed from the wax by the strainers of the special type previously mentioned. This oil, with which there is some solvent, returns with the bulk to the solvent stripping stage. Thus, the material remaining consists of wax, solvent and a small amount of neutral oil. The solvent is stripped from this mixture and returned to the lube plant.

It is not necessary to carry out the rather troublesome operation of 'sweating' the wax to remove the neutral oil, as is required to produce finished wax. Since the oil differs from the wax only in chain length, the mixture can proceed to the oxidation or cracking stages without further treatment. In the present process the feedstock, consisting largely of straight chain hydrocarbons in the range  $C_{16}$  to  $C_{42}$ , is passed to a catalytic cracking stage. Here the higher molecular weight components break down in larger proportion than the lighter ones. By controlled cracking, with recycling, virtually all the feedstock can be converted into the range below  $C_{30}$  and containing about 25% of unsaturated hydrocarbons by weight.

This material is passed to a quenching stage from which the gases are drawn off and used in the production of ethylene, propylene and their derivatives and by-products. Although these account for only about 2% by weight of the charge, they are important in the overall economics of the process because of the high prices they command. The subject, therefore, will be dealt with in some detail in the notes on the economic aspects of the process.

The liquid component of the cracked charge, constituting about 98% by weight of the original feedstock, is passed to a process for the separation of straight chain olefins by extractive crystallisation with urea.\* The extract contains about 95% straight chain hydrocarbons, of which two-thirds are olefinic. It can be arranged that about one-third of the starting material is recovered in this form, so that the olefinic part constitutes two-ninths or about 22% of the original feed. This portion of the cracked stock is converted to finished forms generally as indicated in Fig. 1, the paraffinic residue being returned to the system by admixture with the new feed.

It will be observed that the material passing forward constitutes about 65% of the original charge and is mainly paraffinic in the range from  $C_4$  to  $C_{30}$ . It does, however, contain some unsaturated material which is of advantage in that, being readily oxidised, it initiates the main reaction.

The process of oxidation may precede or follow fractionation of the paraffinic stock. If edible fats are the main objective, it is clearly more economical to carry out the rather complex operations on the desired fraction. Since it is necessary to use chains of approximately twice the required length, the portion up to about  $C_{20}$

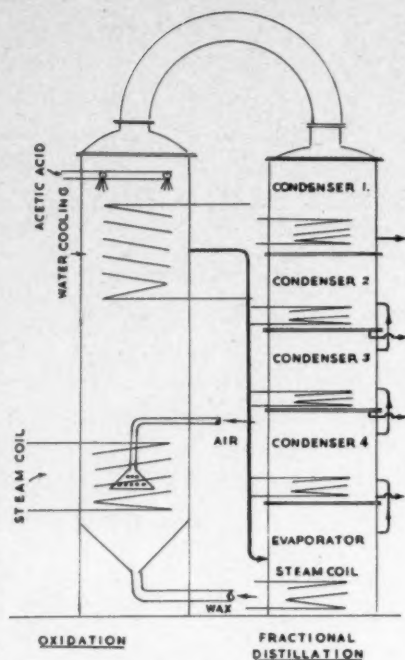


Fig. 2. Conversion of wax to fatty acid fractions by simple batch process.

i.e. boiling below  $650^{\circ}\text{F}$ ., is separated from the charge to the oxidation stage, which thus lies predominantly in the range  $C_{20}$  to  $C_{30}$ . The production of edible fats will be amplified later.

To establish the essentials of the process before proceeding to refinements, it is better to assume that the fatty acids are to be produced for soap manufacture. In this case it is not necessary to fractionate before oxidation and the procedure and equipment for converting the paraffinic feedstock to fatty acids may take its simplest form, which is shown in outline in Fig. 2. The stock is mixed with sodium carbonate and about 0.1% of potassium permanganate and heated to about  $150^{\circ}\text{F}$ . for 15 min. and then proceeds to the air-blowing towers.

Here the main reaction takes place. Air at  $100^{\circ}\text{C}$ . is blown through the charge from the base, whilst acetic acid and manganese soap solutions are sprayed in at the top. Both promote fatty acid formation, the former by providing the carboxyl component and the latter by catalysing the oxidation process. Economically, it is most desirable that the process is continuous and to achieve this it is necessary to separate and remove the required soapstock at the rate at which it is formed beyond a certain proportion. This may be achieved by making the feeds of the various reactants continuous and balancing them by a delivery taken from the point in the height of the tower, where soap concentration is highest. The issuing material consists of a soap solution and a mixture of hydrocarbons in liquid form. The soapstock is removed by centrifuging and the remainder returned to the air tower with the hydrocarbon feed. To limit the formation of

oxidation products other than fatty acids, it is essential to maintain an equilibrium in the towers in which the fatty acid content of the reacting mixture does not exceed about 25%.

Treatment of the soapstock is determined by the economics of the overall process. For example, in the simplest case, in which a soap powder associated with a high proportion of ancillary agents is the final product, it is only necessary to mix the ingredients and spray dry the resulting solution. For solid forms of finished soaps it is necessary to convert the soapstock to fatty acids by treatment with mineral acid, separate the required components by fractional distillation and then convert these back to liquid soap by reaction with the correct solution of sodium carbonate or sodium hydroxide. The blending of these liquid soapstocks with resin, perfumes and colouring agents and the procedure for solidifying, structural modification by plodding, and formation of bars, chips or tablets are identical with those of conventional soap manufacture.

The lower fatty acids, which are by-products of the manufacture of this range of soaps, may be modified by condensation with ethylene to give mixtures of saturated fatty acids of practically any desired chain lengths. Condensation is effected in the presence of a catalyst, e.g. hydrazine sulphate at about  $250^{\circ}\text{C}$ . and 850-900 atm. This process is useful in dealing with accumulated residues resulting from recycling operations in the main oxidation stage. It makes possible the conversion of practically all the products of the oxidation stage to marketable forms by comparatively simple and economical processes.

### Special processes and equipment

It will be observed that the overall scheme for the conversion of waxes to the main products specified is largely an integration of well-known processes and plant. However, in the particular system under consideration there are certain features which have been incorporated to effect economies and improve the products. Notably, these are:

- (1) A special type of separator (see Fig. 3) for the bulk recovery of waxes from distillates.
- (2) Catalytic cracking equipment and catalyst nature and forms specially evolved for maximum economic yields in this particular connection.
- (3) Continuous oxidation of selected fractions for maximum yields of fatty acids in the range most suitable for soaps and edible fats (see Fig. 4).
- (4) Separation of odd from even carbon fatty acids by a two-stage solvent operation.
- (5) Special processes for the maximum conversion of residues to high value products.

Although in the early stages of the developments under consideration slack waxes

\* See 'Extractive Crystallisation with Urea' by E. V. Truter, CHEMICAL & PROCESS ENGINEERING, March 1954.



from lube oil manufacture will be the basic raw material, it will become necessary to extract waxes from wax distillates. Unlike the lube waxes, the cost of extraction of the latter must be wholly charged to the raw material. It was necessary, therefore, to devise a simpler method and this was made possible by the fact that the separation need not be nearly so complete.

The normal solution in such cases is to use strainers instead of filters, but this is not applicable for the present purposes owing to rapid clogging of the fine mesh screens which must be used, particularly for micro-crystalline waxes. A principle widely used in paint strainers was found effective. The essential feature of this is that, if a screen is gyrated at a frequency of around 1,000 cycles per minute with an amplitude of about  $\frac{1}{8}$  in., solid matter stays in suspension well clear of the screen. The liquid portion of the mixture thus passes quite freely through the holes in the screen at a rate inversely proportional to its viscosity. Since there is no clogging of screens, the process can be continuous.

As shown in Fig. 3, the equipment consists, essentially, of a tank about 8 ft. in diameter and 30 ft. high, in the centre of which is suspended a column about 2 ft. diameter and 20 ft. long containing a series of screens equally spaced vertically. This inner column is given a gyratory and vertically oscillatory movement by a motor with an out-of-balance flywheel mounted on the top of a flexible suspension system.

Waxy oil plus solvent is introduced at the top of the inner column and gravitates through the screens. By the time it reaches the outlet at the base it is substantially wax free.

From this outlet it flows into a lower compartment of the main tower, from which it is continuously drawn off. The outlet from this compartment is about 3 ft. up from the base to provide a settling zone for residual waxes. The wax concentrate formed here is returned by pump, periodically, into the main feed.

Wax concentrates in oil and solvent solution above the screens and is led along channels formed by scrolls fixed on the screens to ports in the walls of the inner column, from whence it issues into the annular space between the columns. Since the residence period in this zone is considerable, there is a substantial downward flow of oil plus solvent into the lower compartments. The wax crystals largely stay in suspension in the remaining oil and solvent by virtue of the stirring action of the inner column. From a point about 10 ft. from the top of the outer column, where the wax content is highest, a drain-off pipe conveys the material to the solvent stripping column. Here the wax becomes liquid through the action of the stripping steam and is easily pumped to the cracking stages.

It will be apparent that the procedure described is conducive not only to the removal of the oil and solvent solution in which the wax crystals are suspended, but

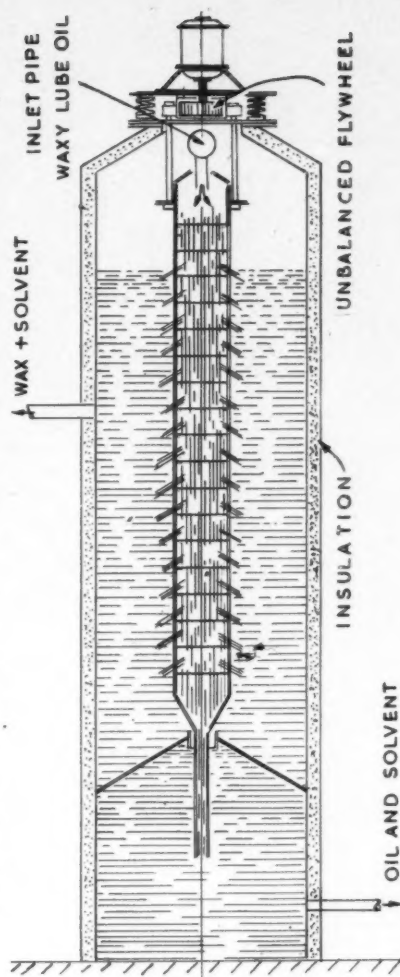


Fig. 3. Gyratory wax separator.

also to that of the oil entrained in the crystal agglomerates. It has been found that such entrainment can be reduced to about one-quarter, e.g. occluded oil content of 40% of the weight of wax can be reduced to 10%.

The main cost of wax removal by this method is that of cooling to crystallise the waxes. It is very important, therefore, to keep this to the minimum by insulation and the most efficient heat exchange. Solvent recovery must also be as high as possible. With proper care in these matters the cost of slack wax separation by this method is only about one-third of filtration by rotary vacuum filters.

#### Catalytic cracking

Cracking is carried out by a modification of the fluid bed method appropriate to the comparatively low throughputs. A type of catalyst and its physical form have been specially evolved which have been found beneficial in controlling the action to give maximum yields of the main fraction required, i.e. paraffins in the range  $C_{20}$  to  $C_{30}$ . By raising the proportion of unsaturated material associated therewith, the control also facilitates the oxidation to the

chief range of fatty acids required, i.e.  $C_{10}$  to  $C_{20}$ . As the method has valuable commercial possibilities, details may not be given.

#### Continuous oxidation

The special features of the oxidation process in this method are directed towards continuity and close control of equilibrium conditions to give maximum yield of higher fatty acids. Over about 25% acids content there is too high a formation of other than mono-carboxylic acids and it has been found far more economical to prevent the formation of undesirable components than to remove them when formed. In the case of acids destined for the production of edible esters it has been found necessary to control the constitution of the paraffinic feedstock very closely and to maintain the acidities below 18% of the reacting mass. Continuous removal of the soapstock seems to be essential to prevent degradation by contact with the other reactants and this is achieved by a recycling operation incorporating centrifugal separation of the soapstock. The reconversion to fatty acids, stripping of odorous volatiles, washing and esterification must be continuous and integrated with the oxidation process. Fractionation, notably the removal of the odd carbon molecules, can be carried out quite separately.

#### Solvent separation of edible fats

As this is a key process developed for commercial application in conjunction with the particular overall scheme under consideration, it is only permissible to state the general principles upon which it is based, thus:

The feed material to the oxidation stage must consist of predominantly straight chain hydrocarbons containing even numbers of carbon atoms in the molecule. In this lies the importance of close control in the catalytic cracking and fractionating stages.

When a mixture of glycerides containing the minimum proportion of odd carbon constituents has been obtained, further reduction of these may be achieved by first pre-treating the mixture with a particular inorganic acid and then carefully fractionating by precipitation of required components from a certain solvent. This latter operation is a particular application of the well-known process by which specific combinations of fatty acids are obtained from natural fatty materials, except in the nature of the solvent. The base material is fully soluble in this solvent at low temperatures, but the higher molecular weight constituents precipitate progressively as the temperature is raised.

Although, in deference to medical opinions, this complication of the process may be necessary, it should be observed that there are conflicting opinions amongst nutritionists as to whether a small proportion of the odd carbon components are harmful to humans. If it is eventually de-

terminated, by tests rather than opinions, that the separation of these constituents of synthetic fats can be less than complete, industrial processes will be appreciably simplified.

That there are some grounds for the belief that this may be the case may be inferred from the fact that there is no conclusive evidence of harm being done to those members of the German armed forces who consumed synthetic fats during World War II. In this connection it is also worthy of note that the triglyceride of margaric acid, which contains an odd number of carbon atoms, has been deliberately incorporated in the diet for diabetics under the name Intarvin. It seems to be established that diabetics are unable to use some of the end-products, e.g.  $\text{CH}_3\text{COCH}_2\text{COOH}$  and  $\text{CH}_3\text{COCH}_3$ , from the  $\beta$  oxidation by which fats are metabolised by successive degradation stages of two carbon atoms. By avoiding the end-products which accumulate in the system when even carbon fats are ingested, definite improvement has been shown. The significance of this example for the present purpose is, of course, in the clear inference that odd carbon glycerides are assimilable by humans. It does not seem to be suggested that diabetics have an advantage over others in this respect.

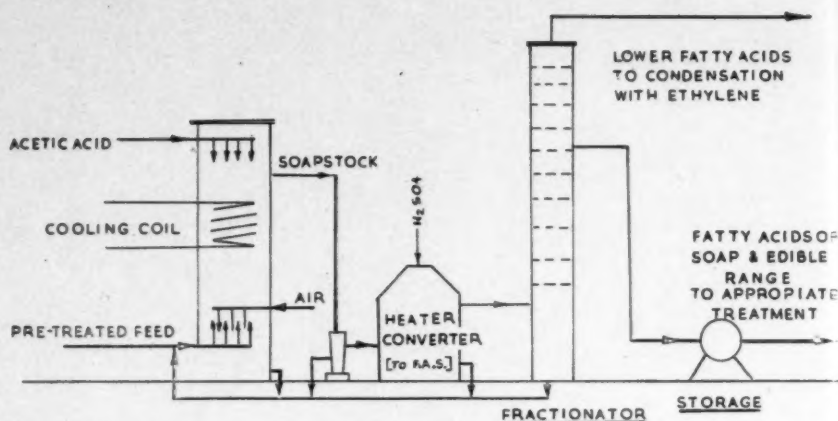


Fig. 4. Conversion of selected fraction of cracked wax to fatty acids for continuous soap or edible fat manufacture.

### Secondary processes

To make as good use as possible of the raw material without unduly extending the range of products, it is advantageous to use processes which would not, otherwise or in isolation, be used for the small quantities involved. Typical of these is the conversion of lower fatty acids to the higher molecular weight, and particularly edible range by condensation with ethylene. By applying a

number of such operations in proper relation to the major processes it is possible and profitable to convert as much as 90% of the base material to not more than six end-products. This matter will be treated later under the appropriate heading of economics.

All flowsheets in the first article in the series, except that at the head of p. 166, were reproduced by courtesy of Foster Wheeler Ltd.

## How the Bromine Industry has Grown

IN A SURVEY published in the German journal, *Chemische Industrie*, of May 1954, of the history and present state of the bromine industry throughout the world, Dr. W. von Haken recalls that a bromine industry has been in existence since 1865, though bromine as an element has been known for 130 years. By 1900, the total world production of bromine had not exceeded 1,000 tons p.a. During the next 25 years or so, production increased slowly. The photographic industry was responsible for nearly one-third of the consumption, whilst nearly two-thirds were taken by the pharmaceutical industry, the remainder being used for laboratory work and various minor purposes.

With the advent of the internal combustion engine, a large demand arose for ethylene dibromide for the manufacture of tetra ethyl lead anti-knock compounds for petrol. This gave rise to the mass production of bromine in the United States. Germany, which was the only country producing bromine at the outset and, in later years, had led the rest of the world, was soon outpaced. World output rose from 8,000 tons in 1930 to 32,000 tons in 1940.

Present world production is estimated at about 100,000 tons p.a. Approximately 70% of all the world's bromine is produced in the United States, about 12½% by Britain and 2% by France. Germany's share was, in 1938, about 16% and Soviet Russia's share 7%, but no statistics are

available concerning the present output of these two countries. Bromine is also produced in Japan, Italy and Spain. In recent years, production has also been restarted in Israel.

The present monetary value of the annual world production of bromine is put roundly at £20 million, equivalent to about 0.15% of the total world chemical production. With the advent of large-scale production, the price per weight unit has dropped very considerably.

On the consumption side, about 90% of the total bromine yield is at present used for the production of ethylene dibromide. The market is therefore highly dependent on the application of the material for one specific purpose, with the inherent danger that the market might collapse if better or cheaper fuel additives are found.

Originally, bromine was extracted from the waste brines of Stassfurt salts and similar deposits. With the greatly increased demand, these sources proved inadequate, and bromine is now mainly extracted from sea water. In Russia, various West Siberian and Crimean lakes are rich in bromine; so are the potassium deposits in the Ural mountains and the Western Ukraine.

In Japan, bromine is produced partly from sea water and partly from lyes rich in magnesium bromide. In Italy, bromine is mainly extracted at the State-owned salt works at Foggia (Apulia) and Cagliari (Sardinia). Spain's comparatively small

bromine production is based on the salterns of Almeria. In Israel, the successor company of the Palestine Potash Co. has restored one of the two chemical works on the shores of the Dead Sea where bromine is won as a by-product of potassium production. E.R.

NOTE.—For a description of the new British bromine extraction plant, see *CHEMICAL & PROCESS ENGINEERING*, April 1954, pp. 115-120.

**Industrial eye protectors for operations other than welding** (B.S. 2092: 1954, 4s. net). This standard specifies the essential requirements for eye protectors suitable for common industrial operations; it extends and supersedes B.S. 955: 1941 (spectacle-type goggles for protection against flying particles). It does not deal with protection against harmful radiation, which is covered separately in B.S. 679 (protective filters for use in welding and similar industrial operations), in B.S. 1542 (equipment for eye and face protection during welding) and in B.S. 1729 (green protective spectacles and screens for steelworks' operatives). Protection from glare is not covered and may be an additional requirement, nor is reference made to face shields or screens.

The standard covers both heavy-duty and light-duty eye protectors, the essential difference between the two being the requirements of the impact test specified in Appendix B.

Attention is drawn to the fact that corrective safety lenses are available.



# Fire Hazards in the Chemical Industry

*New facts about the cause, prevention, behaviour and control of fires, both in industry and in the home, were brought to light through work carried out under the Department of Scientific and Industrial Research and the Fire Offices' Committee in 1953, and they are summarised in a report\* that has just been published. Below we present those parts of the report which are of most interest to the chemical and allied industries.*

## Spontaneous heating and ignition in iron pyrites

THE introduction into the United Kingdom of the flash roasting of finely pulverised iron pyrites as a source of sulphur dioxide in the manufacture of sulphuric acid has led to enquiries on the spontaneous heating and ignition of pyrites. A review of the subject has been prepared, initially for the Factory Department of the Ministry of Labour and National Service, from which it is concluded that some heating is certain to occur in pulverised pyrites stored in bulk to which air has access, and it may do so to a greater extent than with pulverised coal. If the pyrites is free from moisture the risk of dangerous heating may be considerably reduced but it cannot be regarded as non-existent. The extent of self-heating to be expected under practical conditions cannot be predicted. It appears that the risk of actual fire depends on combustible materials such as timber being in contact with the pyrites.

## Mixtures of sodium chlorite and sodium sulphate

A request was received for information concerning the fire hazard of sodium chlorite/sodium sulphate mixtures which are used in an electrolytic process for the production of chlorine dioxide in flour bleaching. Sodium chlorite, which is a powerful oxidising agent and thus presents a fire hazard, is understood to be used in a 1:2 mixture with sodium sulphate. Some guide to the hazard can be obtained by observing the effect of the materials on the burning of common combustibles such as flour or wood. The mixture of combustible and chlorite alone, in equal proportions, presents a hazard certainly equal to, and probably greater than, that of a similar mixture using sodium chlorate. Experiments show that the normal 1:2 mixture of sodium chlorite and sulphate presents a marked fire hazard, and that the hazard remains appreciable even when the ratio is reduced to 1:5.

## Mixtures of acetone and methylene chloride

Another problem examined during the year concerned the fire hazard of a 10:1 mixture of methylene chloride and acetone, the proportions being by volume of liquid. It was calculated that the composition of the vapour given off by the liquid between 10 and 30°C. would be outside the flammable range. This was confirmed by Abel flash point tests between -5 and +30°C., in which no flame was observed.

The flammability limit curves, however, showed that the line representing the composition of the vapour produced by complete evaporation of the mixture (such as would be produced by spillage) approaches very closely the flammability curve for the commercial grade and intersects the flammable range of mixtures with pure acetone. It would thus produce, with pure acetone, a flammable atmosphere with between 80 and 82% of air, which means that if 1 pint of mixture were spilled and completely evaporated it would make the atmosphere flammable in a compartment of 30-cu.ft. capacity.

The results of the test show that, while a flash point determination is useful for pure liquids, it cannot be made the sole criterion of the fire hazard of mixtures containing a non-flammable constituent. This effect is particularly marked if one constituent is a liquid like methylene chloride, which is non-flammable when tested under ordinary conditions but can become flammable under extreme conditions, for example in pure oxygen.

## Fires caused by dust explosions

At the Safety in Mines Research Establishment, Buxton, work has continued on problems associated with dust explosions in factories, in collaboration with the Factory Department of the Ministry of Labour and National Service.

The number of dust samples tested during the year for explosibility in the form of a dust cloud was 69. Those added to Class I—dusts which ignite and propagate flame readily, the source of heat required for ignition being small—included polymethyl methacrylate, vegetable drugs, a mixture of glyceryl monostearate and gum arabic, tobacco dusts, phenol-formaldehyde and urea-formaldehyde synthetic resins, urea-formaldehyde moulding powders, gramophone record dust, sodium phenate, cattle foods, candelilla wax, ground viscose paper, aluminium dust from a metal spraying process, ground aluminium, *para*-nitrobenzoic acid, dust from the scutching of linseed, a mixed flax and jute dust, builders' paste powder, blown zinc powder, peat, *para*-benzyl-phenyl carbamate, liquorice, coffee husk, synthetic rubber, spent oxide and sugar beet pulp.

**Explosion doors.** In a 50-ft. length of 30-in.-diam. gallery, experiments have been completed on the efficacy of a simple hinged explosion door in relieving the

pressure produced by cork dust explosions, and the range of the investigation has been extended by repeating selected experiments with explosions of a provender dust and a moulding powder consisting of phenol-formaldehyde resin with wood flour filler. The explosions of the three dusts—cork, provender and moulding powder—were in ascending order of violence; under certain standardised conditions, with the source of ignition at a closed end and a full-bore opening at the other end, the maximum pressures obtained were 16, 19 and 26 p.s.i., and the maximum values of the mean rate of pressure rise, 150, 300 and 460 p.s.i./sec., respectively.

It was found that with all three dusts the relief afforded by the hinged door did not differ significantly from that afforded by a free opening in the same position. It is evident, therefore, that the hinged explosion door is an effective means of relieving the pressure produced by dust explosions in factory plant. The position of an explosion vent is important in that it has its maximum effect when located near the point of origin of the explosion; thus the maximum pressures quoted above were reduced to 1, 1 and 4 p.s.i., respectively, when a hinged door was provided near the source of ignition at the closed end of the gallery. It is not, of course, possible to anticipate where an accidental ignition may take place in factory plant; in an elevator, however, explosion vents placed at top and bottom would be effective against the known hazards of overheated bearings or friction caused by choked material in the delivery head or boot; intermediate vents may be required according to the nature of the dust and the length of the casing.

A similar investigation to that described above has begun in which bursting and blow-out panels of various materials are used instead of hinged doors. Materials now under test as bursting panels include polythene film in two thicknesses (0.005 and 0.002 in.), cellulose sheet 0.0015-in. thick and a flame-proofed kraft paper. The results obtained so far, in a limited number of experimental arrangements of the gallery, indicate that the thinner polythene film and the cellulose sheet are as effective as an open vent, but that the thicker polythene film and the paper are substantially less so, although they still afford appreciable relief of pressure. Cutters of the type that are placed round the periphery of the panel so as to come into contact with the material as it begins to distend under the pressure do not affect

\*'Fire Research, 1953,' 44 pp. illustrated, H.M.S.O., 2s. 6d.



the bursting strength of the thicker polythene film, but they cause a reduction in that of the paper.

### Use of sprays on liquid fires

After intensive study of sprays on kerosine fires, a comparison has been made during the current year of the effect of sprays with three different sizes of drops on six liquids, namely alcohol (industrial methylated spirit), benzole, petrol, kerosine, gas oil and transformer oil. These liquids cover a wide range of volatilities. They are used extensively in industry and commerce, and are frequently encountered in fire-fighting.

The sprays were produced at a pressure of 85 p.s.i. and delivered at  $\frac{1}{3}$  gal./sq.ft./min. to the fire area. The mass median drop sizes were respectively 0.28, 0.39 and 0.49 mm. Six tests were carried out for each liquid over a range of pre-burning times from 2 to 8 min.

The results show that:

- (1) in general, the mean time of extinction decreased as the volatility of the liquid decreased;
- (2) alcohol, benzole, petrol and kerosine were extinguished most rapidly with the finest spray;
- (3) transformer oil and gas oil were extinguished most rapidly with the coarsest spray.

The experiments throw light on the mechanisms of extinction. With the finest spray there was some evidence that the primary mechanism of extinction was the formation of steam in the flames, followed by smothering and not mere cooling of the flames. The coarsest spray extinguished the higher boiling liquids by steam formation at the liquid surface or by cooling the liquid to the fire point. Measurements of the change in electrical conductivity at the surface of the liquid and an examination of samples taken from the surface within a few seconds of extinction did not reveal any significant evidence that the formation of an oil-in-water emulsion played any part in the extinctions. The coarse spray extinguished the alcohol fire by dilution of the surface layers.

### Petrol storage tank fires

It is now possible to extinguish fires in petrol storage tanks by introducing foam into the tank through the supply lines at the base of the tanks. One advantage of base injection is that the supply lines are unlikely to be damaged in the early stages of the fire, a shortcoming of foam applicators placed at the top of the tank. The foam reaches the surface at low velocity and does not disturb the surface of the petrol or any existing foam layer in the way that can happen with top application, particularly if the petrol level is low and the foam falls some distance in reaching it. The technique has already been used successfully in dealing with fires in tanks of oil fuel, but much experimentation, both in this country and the United States, had

to be done before it could be applied satisfactorily to petrol tank fires.

One problem to be overcome in developing an efficient method of base injection was the selection of a satisfactory expansion ratio for the foam. The best results were achieved with foams of an expansion much lower than that given by the normal branch pipe. Foams of a higher expansion absorbed too much petrol during their passage through the tank and, although they controlled the main fire, on reaching the surface a 'foam fire' developed in the petrol which had been picked up by the foam itself, and this fire gradually destroyed the foam. On the other hand, foam of a very low expansion drained too rapidly to form an enduring protective layer on the surface of the petrol.

### Fuel Cells

(Concluded from page 240)

bearing on future development of this type of cell.

The possibility of combining a high-temperature gas cell with underground gasification has been put forward on several occasions (e.g. Génin, 1953).<sup>21</sup> This is attractive, because the gas produced by such processes has a low calorific value owing to the presence of CO<sub>2</sub> and nitrogen in the product; this makes the design of a heat engine difficult. From equation (11), assuming a constant partial pressure of oxygen at the positive electrode (i.e. 0.2 atm.), the variation of free energy of the CO  $\rightarrow$  CO<sub>2</sub> reaction with partial pressures of CO and CO<sub>2</sub> depends only on the

logarithm of the ratio  $\left(\frac{p_{CO}}{p_{CO_2}}\right)$ , so that

low concentrations of CO in the fuel gas will not depress the free energy change in the reaction markedly, while the presence of nitrogen should have no effect at all.

Redox cells have not yet been demonstrated even on the laboratory scale, although it is probable that this will soon be possible. The theoretical bases of redox reactions have not been fully investigated, and for this reason the assessment of various alternative systems involves lengthy experimental work; consequently it is difficult to decide at this stage whether or not redox cells are likely to become practicable means of generating appreciable quantities of electrical energy. On the other hand, such systems are attractive, because they might almost eliminate thermal losses and enable electricity to be generated from low-grade fuel; also elaborate plant to prevent atmospheric pollution would not be necessary.

Should future developments enable practical application of fuel cells to the generation or storage of large quantities of energy for the public supply to be considered, there would still remain the problems of transmission and distribution arising from the fact that a fuel cell produces low-

voltage direct current. It is probable that the solution to these would involve inversion to alternating current. Whilst this is technically possible, it would undoubtedly increase the cost of generation. For this reason, the first large-scale application of fuel cells would probably be to electrochemical processes requiring a source of direct current at low voltage. It is easy to see that such a development would have a profound effect on chemical industry if the cost were comparable with that of hydroelectric energy generated under favourable conditions. Apart from systems primarily designed for energy storage, which have already been mentioned, there is a possibility of economic application where quantities of hydrogen or other fuel gases are produced as by-products, as in some oil refinery processes and during the operation of coke ovens and blast furnaces. Moreover, only the chemical industry could undertake the design and operation of fuel cells on a large scale, at least initially.

As far as can be judged from the available information, it seems that research on fuel cells, although on a small scale, is being more actively pursued in this country than elsewhere at present. In this article it has only been possible to indicate the main problems and possible solutions. Much detailed theoretical and practical investigation still remains to be carried out before it is even possible to decide whether a large effort in research and development would be economically justifiable.

### Acknowledgment

The author wishes to thank Dr. J. S. Forrest, Director of the British Electricity Research Laboratories, for permission to publish this article.

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# Comparative Efficiencies of American BEET SUGAR REFINERIES-1

Many chemical engineering operations are performed in the sugar-refining industry, so there is particular interest in the fact that since 1920 the beet-sugar industry in America has more than halved labour requirements. The figure in 1951 was less than one man-hour per ton of beets processed. Although the efficient use of capacity and labour force is largely dependent on the size and quality of the beet crop, it still remains true that this achievement has been obtained through continual technological improvements to produce more continuous and automatic operations. Here is an appraisal of the comparative efficiencies of six representative American beet-sugar refineries. There are 80 such refineries in the U.S. producing about a quarter of total sugar consumed there.

FOR many years, the two refining processes of diffusion and slicing had been relatively inefficient and created waste due to prolonged storage. In recent years, however, much man-hour saving has resulted not only from improvements in these two processes but also from an increased mechanisation in handling beets, white sugar and pulp and the addition of automatic control devices. Man-hour requirements for the six plants surveyed in this report\* reflect differences in equipment used and in the volume of operations, degree of beet purity and labour conditions.

## Beet sugar refining process

The extraction of pure sugar from sugar beets may be summarised by the following steps: beet cleaning and slicing, diffusion, juice purification, evaporation, crystallisation and packing. Many refineries perform additional operations such as recovery of additional sugar from molasses, recovery of by-products and pulp preparation.

## Plant characteristics

The six plants selected for this report are representative of the beet-sugar industry in the United States in terms of size, age of equipment, location, and type of production methods.

All plants are members of large multi-plant companies which provide purchasing, sales and administrative functions, and research and analytical control methods. Plant A has a slicing capacity under 2,000 tons per 24 hr., plants B, C, D and E have capacities of about 3,000 tons and plant F has a slicing capacity of more than 3,000 tons. One plant is equipped to use the ion-exchange process, although it was not in use at the time of the survey. Two plants extract additional sugar from molasses by the Steffens process.

## Man-hour requirements

The labour requirements of the six plants range from 0.624 man-hours per ton of beets sliced for plant E to 1.293 man-hours for plant F (Table 1). The

\*Beet Sugar Refining. Distributed in Britain by the British Institute of Management, London, W.1. 5s. net.



Merrick Weightometer automatic scale.

efficiency of plant E is the result of its up-to-date continuous and automatic equipment and controls. By comparison, the larger number of man-hours of plant F include certain operations not performed by plant E and other plants. The man-hours, however, also reflect difficulties in beet receiving, high maintenance hours

and more man-hours at some operations as a result of older equipment.

The remaining plants have similar total labour requirements, yet indicate some differences among individual operations, most of which are the result of the equipment employed.

The number of man-hours required to

Table 1. Man-hour Requirements per Ton of Beets Sliced and per 100 lb. of Sugar Produced, by Type of Labour, in Six Selected Beet Sugar Refineries. U.S.A., 1951.

Type of labour	Plant					
	A	B	C	D	E	F
Man-hours per ton of beets sliced						
Total factory labour .. ..	0.887	0.730	0.727	0.886	0.624	1.293
Direct labour .. ..	.538	.463	.442	.588	.400	.913
Indirect labour .. ..	.349	.267	.285	.298	.224	.380
Man-hours per 100 lb. of sugar produced						
Total factory labour .. ..	0.329	0.283	0.259	0.348	0.232	0.486
Direct labour .. ..	.200	.179	.158	.231	.149	.343
Indirect labour .. ..	.129	.104	.101	.117	.083	.143

process a ton of sugar beets and to produce a ton of sugar are shown by type of labour and by operations in Tables 2, 3, 4 and 5.

With certain exceptions (such as ion exchange, an operation not used in 1951 by any of the surveyed plants), the operations in beet-sugar refining are identical in all plants. Differences in the man-hour requirements per ton may be attributable in most cases to the type of equipment used, the number of employees at each operation and in maintenance functions, and to operations such as the Steffens process which is not performed in all plants.

The labour requirements do not include man-hours of persons engaged in office work, purchasing, selling and other general administrative duties, or of persons in the parent company offices or testing and research laboratories. The number of employees at each operation is generally largest on the first shift and is considerably reduced for the two following shifts, particularly in maintenance functions.

### Operations in a typical plant

New continuous-type equipment, automatic instrument controls and co-ordination in steam and vapour use have reduced the total labour requirements of a modern American beet-sugar refinery to less than 15 man-minutes per 100-lb. bag of white sugar. This may be illustrated by a summary of the operations of plant E, which operates at a daily slicing rate one-third greater than designed capacity, and has the least number of man-hours required per ton of the plants surveyed in this report. Because of the location of the refinery in an area where high temperatures do not allow long storage of the beets, both speed and co-ordination of beet slicing to receipt of beets and oversize equipment at critical points were necessary.

A maximum of 4,500 tons of beets a day are delivered by railroad cars and trucks, weighed, tested, and pumped by two 5,000-gal./min. pumps through flumes to the next process. About 60% of the flume water is recirculated. After washing and trash removal, the beets pass over a magnetic pulley for the removal of tramp iron, and are fed to four Ogden slicers. The battery operator co-ordinates the speed of the slicers to the requirements of the diffuser. These slicers are each driven by a 50-h.p. gear-reduction motor and can be varied in speed from 60 to 120 r.p.m. A Merrick Weightometer automatic recording scale weighs the cosettes entering the diffuser and simultaneously regulates the amount and flow of water and its temperature (140°F.) to the diffuser.

The diffuser is a Silver 21-cell continuous type, one of 16 in use in the industry. The unit is installed in two banks, 9 cells over 12 cells, through which perforated steel shelves move, driven by ten 3-h.p. d.c. motors. The unit is operated by one man only, a saving of about 168 man-hours per 24 hr. over

Table 2. Direct Man-hour Requirements per Ton of Beets Sliced by Operation or Labour Account in Six Selected Beet Sugar Refineries. U.S.A., 1951.

Operation or labour account	Plant					
	A	B	C	D	E	F
Beet end:						
Receiving .. .. .	0.020	0.026	0.061	0.029	0.021	0.077
Handling (flumes, trash catchers, beet washers) .. .	.121	.040	.062	.067	.040	.068
Slicing (weighers, knife filers, setters, picking table) ..	.045	.040	*	.044	.040	*
Diffusion (battery foremen, cell fillers, dumpers, pulp handlers) ..	.061	.008	.022	.055	.008	.114
Carbonators (sulphur burners, tankmen) .. .. .	.015	.008	.008	.022	.008	.011
Filter pressmen, laundry men ..	.045	.072	.051	.077	.059	.112
Evaporators .. .. .	..	.008	.008	.011	.088	.011
Utility men .. .. .	.015	.021	.012	†	.008	.030
Lime kiln .. .. .	.030	.018	.044	.055	.024	.059
Reclaiming .. .. .	†	†	†	†	†	.019
Sugar end:						
Boilers, crystallisers, helpers ..	.030	.032	.032	.022	.027	.043
Granulators .. .. .	.015		.011	.008	.015	.015
Centrifuges, melters .. ..	.045	.058	.066	.066	.048	.163
Utility men .. .. .	†	.013	.006	.004	†	.015
Packing .. .. .	.096	.119	.024	.125	.101	.081
Steffens operations .. ..	†	†	.037	†	†	.095
Total direct labour .. ..	.538	.463	.442	.588	.400	.913

\*Included in handling.

†Operation not performed.

Table 3. Direct Man-hour Requirements per 100 lb. of Sugar Produced by Operation or Labour Account in Six Selected Beet Sugar Refineries, U.S.A., 1951.

Operation or labour account	Plant					
	A	B	C	D	E	F
Beet end:						
Receiving .. .. .	0.0075	0.0103	0.0216	0.0116	0.0079	0.0288
Handling (flumes, trash catchers, beet washers) .. .	.0448	.0153	.0222	.0260	.0149	.0256
Slicing (weighers, knife filers, setters, picking table) ..	.0168	.0154	*	.0173	.0149	*
Diffusion (battery foremen, cell fillers, dumpers, pulp handlers) ..	.0224	.0031	.0080	.0217	.0030	.0428
Carbonators (sulphur burners, tankmen) .. .. .	.0056	.0031	.0239	.0087	.0030	.0504
Filter pressmen, laundry men ..	.0168	.0277		.0304	.0219	
Evaporators .. .. .	..	.0031	..	.0043	.0030	..
Utility men .. .. .	.0056	.0082	.0044	†	.0030	0.1120
Lime kiln—Reclaiming .. ..	.0112	.0072	.0155	.0217	.0089	.0220
Sugar end:						
Boilers, crystallisers, helpers ..	.0112	.0123	.0114	.0087	.0099	.0161
Granulators .. .. .	.0056		.0033	.0043	.0030	.0057
Centrifuges, melters .. ..	.0168	.0226	.0234	.0260	.0179	.0612
Utility men .. .. .	†	.0051	.0022	.0014	†	.0056
Packing .. .. .	.0355	.0462	.0084	.0491	.0378	.0305
Steffens operation .. ..	†	†	.0130	†	†	.0360
Total direct labour .. ..	.1998	.1796	.1575	.2312	.1491	.3432

\*Included in handling

†Operation not performed

conventional batch-type units. The diffuser extracts about 98% of the sugar present in the beets in a cycle time of about 80 min., at a uniform automatically controlled temperature (70°C.).

Although most refineries use either the Silver continuous diffusion system as described for this plant or the Roberts batch-type system, another type used is the Oliver-Morton continuous diffusion process. This system consists of a line of 24 to 28 tanks set at a slight incline through which water flows by gravity, the cosettes being moved in the opposite direction by means of a scroll and lifter paddles.

In using this method the loss of sugar

was reported to have been reduced from 3.10 to 1.86 lb./cwt. In addition, about 15 lb. fewer of juice, with a higher sugar content, is drawn off, with resulting savings in fuel required for evaporation.

Other advantages are low initial cost, simplicity of operation, and flexibility. The speed of drive and the number, size and arrangement of cells may be changed to meet different requirements, and removable covers make all parts of the mechanism easily accessible for inspection or adjustment.

Diffusion juice (about 14 Brix) is pumped to heaters where its outflowing temperature is automatically controlled at



Table 4. Indirect Man-hour Requirements by Operation or Labour Account in Six Selected Beet Sugar Refineries, U.S.A., 1951.

Operation or labour account	Plant					
	A	B	C	D	E	F
<i>Per ton of beets</i>						
Total indirect labour .. ..	0.349	0.267	0.285	0.298	0.224	0.380
Plant supervision .. ..	.076	.034	.039	.048	.040	.035
Boilerhouse .. ..	.040	.032	.010	.055	.016	.015
Laboratory .. ..	.066	.053	.074	.055	.045	.052
Maintenance .. ..	.081	.069	.078	.074	.048	.185
General* .. ..	.086	.079	.084	.066	.075	.093
<i>Per 100 lb. of sugar produced</i>						
Total indirect labour .. ..	0.1288	0.1036	0.1013	0.1171	0.0835	0.1429
Plant supervision .. ..	.0280	.0133	.0140	.0188	.0149	.0133
Boilerhouse .. ..	.0149	.0123	†	.0217	.0060	†
Laboratory .. ..	.0243	.0205	.0263	.0217	.0169	.0197
Maintenance .. ..	.0299	.0267	.0312	.0289	.0179	.0750
General* .. ..	.0317	.0308	.0298	.0260	.0278	.0349

\*General includes watermen, watchmen, sweepers, janitors and supply handlers

†Information not available

Table 5. Production and Related Statistics, Six Selected Beet Sugar Refineries, U.S.A., 1951.

Plant operating data	Plant					
	A	B	C	D	E	F
Length of campaign days ..	61	107	107	112	76	107
Tons of beets sliced .. ..	96,164	323,298	240,929	243,095	228,781	510,682
Sugar in beets, % .. ..	16.41	15.92	14.58	15.65	16.51	14.56
Sugar losses, % .. ..	2.89	3.03	0.56	2.92	3.10	0.93
Battery .. ..	.23	.20	.26	.39	.24	.31
Lime cake .. ..	.02	.04	.05	.04	.02	.03
Molasses .. ..	2.60	2.37	.00	2.20	2.86	.00
Steffens filtrate .. ..	.00	.00	.16	.00	.00	.08
Unaccounted .. ..	.04	.42	.09	.29	.03	.51
Tons of sugar produced ..	13,005	41,720	33,803	30,994	30,697	67,957
Powdered .. ..	199	550	none	134	52	1,420
Tablet .. ..	none	none	none	none	none	none
Liquid .. ..	none	none	5,500	none	none	19,594
Tons of pulp produced:						
Wet .. ..	26,445	none	82,000	none	none	none
Dried .. ..	none	19,443	none	12,513	15,990	33,746
Tons of molasses:						
Not processed .. ..	4,370	14,275	none	9,985	12,517	none
After processing .. ..	none	none	1,841	none	none	7,910
Tons of sugar packed:						
100-lb. bag .. ..	11,959	27,379	12,420	15,986	9,119	38,931
25-lb. bag .. ..	156	783	500	804	none	504
10-lb. bag .. ..	1,196	8,604	1,599	6,582	609	4,880
5-lb. bag .. ..	691	4,404	1,043	3,938	952	2,328
Other .. ..	none	none	18,231	none	19,970	21,434

85 to 90°C. Tubes from these heaters are arranged so that they may be withdrawn singly to remove scale. Closed heaters are replacing open injection heaters because a closed heater prevents the condensate from diluting the sugar liquor and will operate on a lower-pressure vapour. The heated juice then enters the continuous carbonation systems through a 14-ft.-diam. Benning carbonator where the pH is automatically controlled. A Benning carbonator replaces the first and second tanks in the conventional Dorr carbonation system, with savings in equipment cost and space occupied. However, there is a disadvantage in a single unit requiring the refinery beet end to be shut down if the carbonator becomes so scaled as to require cleaning.

The glass-calomel electrode units develop a small voltage, determined by the pH and temperature of the solution, which is automatically and continuously recorded by a controlling potentiometer. The

control unit regulates the addition of kiln gas or liming reagent. The gassed, limed juice, under a pressure of 7 p.s.i., is clarified in a 28-ft. Dorr thickener and heated by a third vapour to an automatically controlled temperature of 85°C.

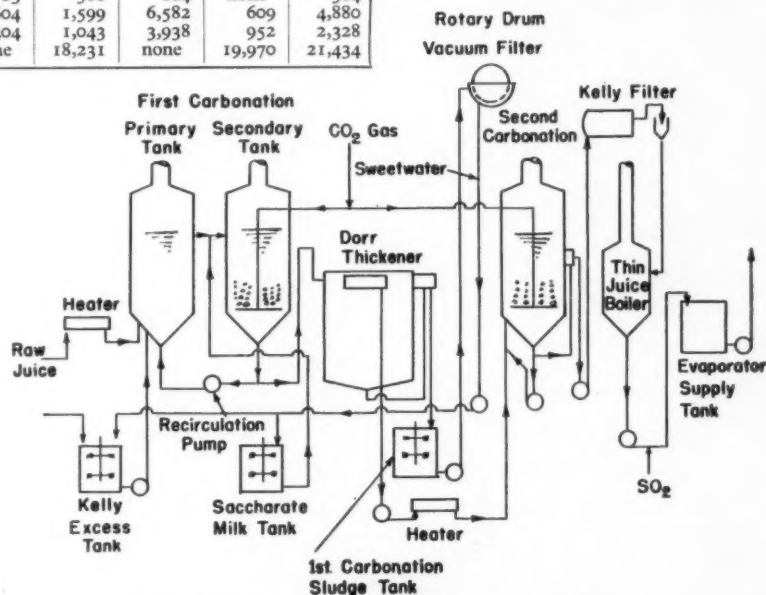
After the second carbonation in which the pH controller regulates the amount of gas introduced, the juice is filtered and pumped to the sulphur tower. The amount of sulphur dioxide gas introduced is automatically controlled by a pH instrument. The thin juice from sulphitation is pumped to a boiler where temperature (98°C.) and juice level are automatically controlled, and to heaters (148°C.).

Continuous carbonation systems are now widely used and offer large savings in labour and maintenance over the older batch-type methods. In 1920, no known continuous systems were in use in the United States; in 1947, more than 66% of the refineries had continuous first carbonation and more than 94% had continuous second carbonation.

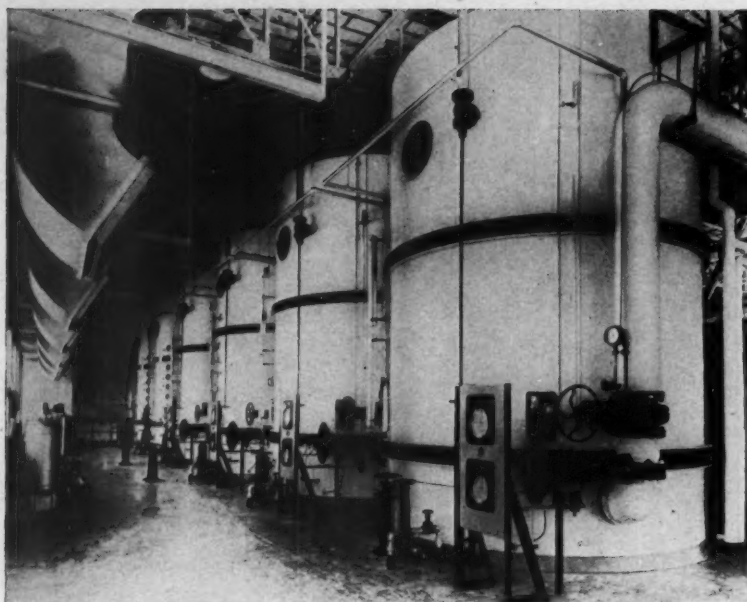
Because of transportation costs, if the refinery is located at a distance from the supplier, sulphuring by the addition of liquid sulphur dioxide is seldom used, although the method eliminates many of the difficulties arising from the use of the sulphur stove.

The Swenson five-effect, long-tube evaporators using automatic-pressure controls are so designed that the vapours provide heat for numerous other operations. The flow of juice (13.4 Brix) to the first effect is automatically controlled, and constant juice levels are automatically maintained in all effects.

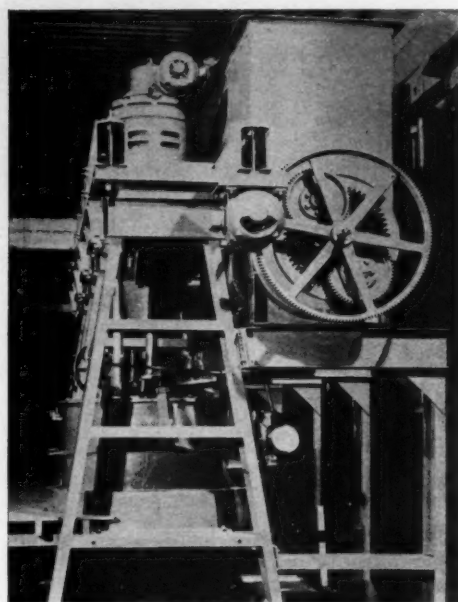
The thick juice effluent from the fifth effect is blended with centrifugal wash-syrup and high-raw melted sugar and is filtered in seven plate-and-frame filters,



Dorr system of continuous first and second carbonation.



Calandria-type vacuum pans with automatic controls.



Centrifugal station, side view.

using a refined diatomaceous filter aid. The high-quality liquor goes to a storage tank (1,620 cu. ft. capacity), also with automatic temperature control, whence it is drawn by vacuum to the two white pans.

The calandria-type Stearns-Rogers vacuum pans have automatic pressure controls, and vapours are drawn off with automatically operated water-jet condensers. Calandria-type pans can operate on much lower steam pressure than coil pans. There is no successful type of automatic vacuum pan controller for beet massecuites which can cover all variables, although it is used in cane-sugar refining. The massecuite from a strike flows to a mixer (1,300 cu. ft. capacity) and then to six centrifugals.

The centrifugals are 40 in. in diameter, 30 in. deep and run at 1,600 r.p.m., with individual motors and fluid clutch, completely automatic except for filling and discharging. In the companies surveyed in this report, two to three centrifugals are operated by one man who, in some cases, merely pushes a button to load and start the cycle. The sugar is then conveyed (510 lb./min.) by scroll and elevator to the wet-sugar bin (30,000 lb. capacity) and then to a *Rotolouvre* granulator.

Air, purified by ionisation through a 13,000-volt, d.c. grid *Precipitron*, enters the drier at an automatically controlled temperature. In this type of drier the air is forced through the sugar instead of the sugar being moved through the air, with a claimed increase in lustre preservation.

The sugar is then elevated at a rate of 505 lb./min., screened, automatically weighed by 100-lb. lots, and dumped into one of four cylindrical bulk bins each 50 ft. in diameter, 106 ft. high, and holding 10 million lb. Air, dried by a calcium chloride

dehumidifier, is circulated in the bins to maintain a low relative humidity.

White sugar is loaded in bulk on railroad cars or trucks, or packaged in 5-, 10-, 25- or 100-lb. paper or cloth bags. The St. Regis valve-type, 100-lb. paper-bag packer eliminates the need for sewing or gluing. After the bag is filled it is removed from the spout, and the paper valve is folded in, preventing leakage. One-hundred-pound bags may be packed with this apparatus at a rate of more than 500 bags an hour. Bags are conveyed by inclined belt elevators to the stacking level in the air-conditioned warehouse.

Plant E was the first American refinery to use only one steam generator, rated at 150,000 lb. of steam an hour at continuous operation. The unit burns about 4 million cu. ft. of natural gas each 24 hr., and generates steam at 410 p.s.i. at 575°F. High-pressure steam is used for a 3,000-kw. turbogenerator, an Elliott blower, and the boiler feed pumps. The turbogenerator develops power at 2,300 volts for the 300 motors used in the plant, and is fractional to 250 h.p. The Elliott blower draws and feeds the carbon dioxide gas at the rate of 5,500 cu.ft./min.

The beet slicers, requiring 2,500 lb. of steam an hour at 100 p.s.i. at the knife-cleaning nozzles, and the La Feuille crystallisers are the only units which do not derive steam from first evaporator effect. By means of automatic pressure controllers which add exhaust steam to prevent pressure drops, pressure is stabilised in the first three effects, thereby guaranteeing a constant supply of steam to equipment drawing on these units for heat.

The fuel economy of a refinery is also influenced by the quality of the beets; an increase from 17 to 18% sugar in beets

will reduce fuel requirements more than 6 million calories per bag of sugar produced.

In addition, the plant is air-cooled at the rate of 330,000 cu. ft. of air a minute and ventilated for the workers' comfort.

*This study of beet sugar refining in the U.S.A. will be continued in a later issue, when the comparative plant characteristics for the six factories already discussed will be given. The ion exchange and the Steffen processes, and the recovery of monosodium glutamate will also be described.*

**Silesters.** Silicon esters are used as bonding agents for refractory fillers in a number of highly specialised industries. Ethyl silicate, as a chemical compound, has been known since the middle of the last century. However, it is to the work of Kipping and his co-workers in the early part of this century that we are indebted for a proper understanding of the properties of this and other organic compounds of silicon. The property of ethyl silicate, which makes it so valuable as a bonding agent for refractories, is its ability readily to undergo hydrolysis in the presence of water. When this hydrolysis takes place, it yields a silicic acid gel and finally silica. A refractory so bonded has an excellent strength in both the green and fired states.

These points are explained in a 24-p. illustrated booklet issued by Monsanto Chemicals Ltd., which describes the applications of the different Monsanto silesters. These applications include investment casting, making precision piece moulds, permanent ceramic moulds, high-frequency furnace linings and cast refractories.

# Stress Distribution in Welded Pressure Vessels

IN the design and manufacture of welded pressure vessels, the aim is to produce a vessel which will not fail and yet which is no thicker, heavier or more expensive than necessary. The questions of thickness and weight are not only economic ones, they may also determine the feasibility of constructing the vessel at all.

The designer must therefore study all possible ways in which his vessel might fail, and determine the properties of the material required to resist each form of failure. In a paper presented to the Institute of Petroleum, Mr. T. B. Webb, chief research engineer of Babcock & Wilcox Ltd., pointed out that, apart from bursting at the first application of pressure—which should be a thing of the past—the ways in which a vessel may become unfit for service are:

(1) By straining or deforming at a mechanical joint sufficiently to permit leakage due to:

- (a) elastic strain;
- (b) rapid plastic strain;
- (c) slow plastic strain at high temperature (creep).

(2) By development of cracks which permit leakage due to:

- (a) brittle fracture at the first application of pressure;
- (b) repeated application of pressure stress at moderate temperature;
- (c) repeated rapid temperature change resulting in thermal gradients and stress;
- (d) continued application of stress at high temperature.

In all cases failure, if it occurs, will originate from a place of high stress. It is therefore essential to know as much as possible about the stress level in all critical parts of the vessel, and the factors which determine it.

Stress raisers might be classified as regional and local, although the distinction is really a matter of degree.

## Regional stress raisers

A regional increase of stress always occurs where there is a junction between two shapes whose natural mode of straining differs. An example is a cylindrical vessel having hemispherical ends of the same thickness. For a given internal pressure the circumferential membrane stress in the cylinder is about twice that in the hemispherical end. If these two components were free to expand independently of each other, the cylinder would therefore strain diametrically about twice as much as the hemisphere, but as they are attached, the hemisphere partly restrains the cylinder, and this causes bending stresses in the region of the junction which are additional to the membrane stress. Even higher stresses result if the cylinder has a flat end. The cylinder is restrained from diametral strain by the end and, therefore, becomes barrel shaped. The end, however, becomes

concave, and the resulting bending stress at the junction is very high indeed.

The stress can also be high at the heel radius of the well-known ellipsoidal and arc dished ends, if the heel radius is small and the dishing radius large. In the early days there were some catastrophic failures of boiler drums and steam and air receivers due to fatigue cracks developing uniformly round the highly stressed heel radius, permitting the ends to blow off in service. Since that time there has been increasing understanding of the stress system in dished drumheads, leading to the adoption of better shapes. The maximum regional stress in a well-designed dished end is now often no more than one and one-half times the circumferential stress in the cylinder to which it is attached.

Another form of regional stress raiser which adds bending stress to the basic membrane stress is any departure from circularity in a cylindrical or spherical surface, e.g. ovality of a welded cylinder. Application of fluid pressure causes the part to alter shape towards the true circular form, with resultant local bending stress.

Perhaps the commonest form of stress raiser is the hole. If a flat plate is stressed in the direction top to bottom by a uniform tension  $T$ , the presence of a single hole will locally modify the stress distribution to produce a tension of  $3T$  at the sides of the hole and a compressive stress of  $T$  at the top and bottom of the hole. In a cylinder, where the uniform circumferential stress is  $T$  and the longitudinal stress therefore  $\frac{1}{2}T$ , the stresses at the periphery of a single hole will be  $3T - \frac{1}{2}T = 2\frac{1}{2}T$  at the sides, and  $3 \times \frac{1}{2}T - T = \frac{1}{2}T$  at top and bottom. In a sphere, where there is a uniform stress in all directions of  $T$ , the stress round the periphery of the hole will be  $2T$ .

Whether there is one or a group of holes in a plate carrying a given load, the stress round a hole is not much affected. In other words, the stress round a hole is more a function of the stress in the undrilled plate than of the stress in the ligament between holes.

It will be appreciated from the above that the diametral strain under fluid pressure of a hole in a vessel is correspondingly greater than the strain of the undrilled plate, and in a cylinder the holes become oval. Any attempt to reduce the stress by adding additional material, or 'compensation,' can do so only by restraining the diametral and oval strain of the hole.

## Strain measurement

The stress distribution in drum ends, around holes, and in many other shapes which cause regional increases is amenable to calculation by the classical theories of elasticity. To check calculation, or to find the stress distribution where calculation is too difficult, measurements of strain in full-sized vessels or in models can easily be

undertaken. Mechanical strain gauges have been available for many years, and during and since the second world war electric resistance strain gauges have come into common use. These consist of a small grid of fine wire, a fraction of an inch in length, cemented in insulation to the surface of the vessel. The strain of the vessel is transmitted to the wire, and causes a small change of electrical resistance, which can be measured with sufficient accuracy to detect strains corresponding with a stress in steel of a few hundred pounds per square inch.

Techniques have also been developed for attaching the gauges inside a vessel and proofing them against the water used for applying fluid pressure. An investigation at present being made to find the optimum amount and proportions of the manhole reinforcement has demonstrated clearly that too much reinforcement is as harmful as too little, and that some of the current empirical rules do not achieve the lowest possible stress levels. The larger the volume of reinforcing material, the larger the force required to make it follow the strain of the vessel, and this increases the stress at the worst place, in and around the weld attaching the reinforcement to the vessel.

## Local stress raisers

The more common local stress raisers are sharp changes of section, such as fillet welds, surface marks, defects in welds, small holes, corrosion pits, intergranular oxide penetration, etc.

They are far too small for the stress to be measured by strain gauges and, while it is possible to calculate their effect in an ideal elastic solid if their shape is known, experience shows that they do not have the enormous effect that calculation would suggest, perhaps because they are of the same order of size as the inhomogeneities in steel.

The only satisfactory way of evaluating their significance therefore is to carry out a destructive test designed to produce as closely as possible the conditions of service, or at least to subject the part under test to a type of loading known to be sensitive to local stress raisers.

For pressure vessels this requires pressure fatigue testing, and it is the practice of Babcock & Wilcox Ltd. to test in this way, by model or full-scale prototype, as far as possible every new shape or change in constructional detail. Equipment which was constructed more than 20 years ago for carrying out hydraulic fatigue tests on pressure vessels in conjunction with the works' hydraulic mains working at 2,000 p.s.i., and works at 6 cycles/min., has been most valuable in providing data on the service capabilities of both large pressure vessels and smaller components such as welded tees.

(Concluded on page 262)



# Problems in the Flash Roasting of Pyrites

THE development of large-scale process techniques for the instantaneous or flash decomposition of pyrites and similar sulphidic ores has mostly occurred during the last 20 years. In a large measure this has been due to the fact that considerable tonnages of finely divided flotation concentrates have become available. The earliest development of these processes of flash decomposition took place in North America, principally in Canada, and later in the States, and during the war years the development has spread to Europe. In Sweden in particular there has been a very large-scale development of flash decomposition techniques and also since the war there has been considerable development in Germany, and also of course more recently in the U.K.

In a paper presented to the Fertiliser Society recently, W. H. Coates, B.Sc., A.M.I.Chem.E., surveys modern methods of flash roasting which have been developed for the treatment of sulphide ores. The processes described include the Cominco process, the Nichols-Freeman process, fluid or turbulent bed processes, the turbulent layer process and the Dorr fluo-solids process.

From this survey, the author concludes that undoubtedly the more extensive use of these systems of roasting, which in a large measure are using finely divided pyrites, will immediately produce a secondary problem concerning the successful exploitation of the high grade iron oxide available as a by-product. Because of the low partial pressure of oxygen in the furnace, the oxide can be produced almost entirely as  $Fe_3O_4$ , which from a chemical standpoint is a highly desirable raw material for the iron making industry. Unfortunately, the iron maker cannot readily use the finely divided product directly in his furnaces, and furthermore, because of the increasing pressure on his already overloaded sintering plants, is reluctant to undertake the sintering of it. A process is, therefore, urgently required where the acid maker can himself prepare, preferably on his own site, a sulphur-free cinder of satisfactory physical characteristics which can be conveyed directly to the blast furnace or similar furnace. An attractive feature of such a process, if it could be developed, would be that it could include the recovery of the residual sulphur values in the cinder as  $SO_2$  which could be led back to the pyrites roasting furnace.

## Reducing sulphur trioxide output

The flash roasting process which has been largely employed in the U.K., and which for this reason is discussed in some detail in the paper, is the Nichols-Freeman process. The author points out that the relatively high proportion of  $SO_3$  which this type of operation has produced has been a disappointment to new users of this

plant in the U.K. It has been shown in a series of tests carried out at Grimsby when operating on a dry ground massive Kalavassos ore, that the  $SO_3/SO_2$  ratio in the gases leaving the furnace follows the theoretical that one would expect at various temperatures.

However, tests carried out on other plants, particularly in Sweden, indicate that this is not always the case, and it is believed that this difference is largely accounted for by the very considerable difference in the surface area of the iron oxide calcine which is present in the Grimsby operations as compared with the operations in Sweden. It is a well known and established fact that  $Fe_2O_3$  is a catalyst for the oxidation of  $SO_2$  to  $SO_3$ , and with the increased surface area present in the Grimsby operations, there will be, because of this, a greater tendency to approach the theoretical  $SO_2/SO_3$  equilibrium for any given temperature. In a similar manner, it has been shown that the Grimsby plant, when using finely divided ores, produces much more  $SO_3$  by oxidation across the boiler than is experienced in those plants which are using rather coarser ores. Associated with this enhanced catalytic activity is the effect of the large surfaces exposed, on the sulphation of iron oxide at temperatures in the neighbourhood of  $350^\circ C.$  upwards. It is believed that this factor is largely responsible for the difficulty which has been experienced in scavenging discharge electrodes of the electrostatic precipitators. The sulphation reaction referred to above is not to be confused with that which occurs at lower temperatures due to the formation of  $H_2SO_4$  mist.

The production of such relatively high proportions of the total sulphur oxides as trioxide in these plants has resulted of course in the production of relatively large amounts of 'drip' acid which normally cannot be used because of contamination. In general, it is believed that the following factors are of importance in the operation of suspension roasting plants if it is desired to keep the sulphur trioxide content to a minimum:

- (a) Highest possible  $SO_2$  concentration in the furnace so as to reduce the partial pressure of the oxygen to a minimum.
- (b) Highest possible operating temperature in order that equilibrium conditions will favour formation of  $SO_2$  rather than  $SO_3$ . This maximum temperature is largely determined in this operation by the necessity of avoiding cinder slides which can occur particularly if the cinder is not completely desulphurised.
- (c) In the preparation of the feed product, great attention must be paid to the reduction of the amount of fines present, particularly in the range of less than 20 microns, where the surface of the resultant cinder increases rapidly with decreasing size and because of this enhances catalytic oxidation of the dioxide.
- (d) The copper in the feed should be as low as possible. The effect of this has not been so well established in the U.K., but it has been seen elsewhere.

## Recent publications

**Brazing alloys.** A full description of *Silvaloy* silver brazing alloys is given in a pamphlet from Baker Platinum Ltd. The physical properties of the alloys are given, such as grade, melting range, maximum stress and hardness. A brief account of their general characteristics is also given.

**Centrifugal filters.** The many applications of Bird centrifugal filters are outlined in a 12-page booklet from Vickers Ltd. The machines can handle slurries which are thick or thin, hot or cold, coarse or fine, and which vary in solid contents and volume. The separation of the solids from the liquor takes place rapidly. In fact, the solids are rarely in the machine for more than 15 sec. The separation of the solid from the liquid is readily controlled, so that unwanted fines are discharged with the filtrate and do not contaminate the product. In the case of explosive or toxic materials, the filter can be made vapour-tight. In any case, the filtering operation is entirely enclosed, and dust and dirt cannot get into the system.

**Petroleum research.** From its earliest days Anglo-Iranian Oil Co. has been keenly aware of the value of research and has built up an elaborate organisation equipped to investigate every kind of problem relating to petroleum. Today its main research station, at Sunbury-on-Thames, England, covers 19 acres and employs over 600 men and women. The work done there—ranging from the testing of oil-heated chicken brooders and the breeding of flies for the evaluation of insecticides to the development of new processes and refinery units by elaborate pilot plant tests—is fully described in a new illustrated booklet produced by Anglo-Iranian, 'Research at Sunbury.'

**Processing tungsten ores.** A revised brochure on the beneficiation of tungsten ores has been issued by the Mineral Dressing Department of American Cyanamid Co.

The new brochure describes various methods of processing tungsten ores, particularly the froth flotation processes used on western U.S. ores.

# Plant and Equipment

## Furnaces for chemical and other processes

The British firm of Birwelco Ltd., Birmingham, are to manufacture under licence Petrochem-Isoflow furnaces, previously obtainable only from the U.S.A.

As offered by the Petro-Chem Development Co. Inc., New York, Petrochem-Isoflow furnaces are claimed to provide uniform heat distribution as the result of the following design characteristics:

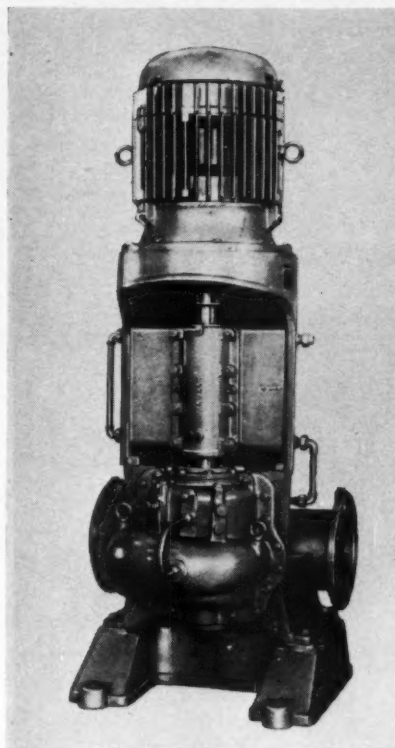
- (1) Individual burners, symmetrically spaced with relationship to the tubes, create a symmetrical flame pattern with relation to the heating elements.
- (2) The metal cone at the top of the combustion chamber re-radiates to the tubes, also diverts products of combustion progressively closer to the tubes, and combines the proper proportion of radiant and convection heat to give the uniform heat intensity at the upper portion of the combustion chamber.
- (3) The combustion gases are diverted behind the tubes so that the gases recirculate from the top of the heater downward, behind and between the tubes, thus increasing the heat input to the rear of the heating elements by convection.
- (4) The recirculated gases also serve to reduce the combustion temperature, reducing the heat intensity at the bottom of the furnace.

Birwelco Ltd. are engineers, fabricators and builders of special process plant, and also manufacturers under licence of Brown Fintube products, which are marketed by their subsidiary company, Brown Fintube (Great Britain) Ltd.

## Electronic counting

The electronic counter, type N.851, and batch counter, type N.808, developed by Airmec Ltd., are designed for the counting and automatic batching of mass-produced articles of any shape or size. The maximum counting speed of both counters is 3,000/sec. and different units can be used with them to record the counts as 10s, 12s, 16s or multiples of these figures. The articles to be counted are normally arranged to interrupt the light beam falling on a photo cell, and the electrical signals so derived are fed to the counter which totals them.

**Batch counter, type N.808.** This operates as a predetermined electronic counter, i.e. it will count to a given (predetermined) number, and when this figure has been reached it will perform some operation, and then reset, if required, to zero. It can be used firstly, therefore, for counting exact numbers of articles into



The 'Nobox' pump, which is fitted with a corrosion-resistant hydro-dynamic seal, making it suitable for handling many corrosive and abrasive liquids.

containers automatically and continuously. When each container has received the correct number of articles a trapdoor or chute is operated and the stream of articles is deflected into the next container. Secondly, it can be used to control any machine which carries out operations to a programme. For example, it can count the number of 'zip' fasteners punched out by a fastener manufacturing machine, and arrange to interrupt the metal feed so that complete fasteners of any required length are manufactured. Thirdly, it can be used for cutting material such as cloth, plastic, veneer, etc., into predetermined lengths. Fourthly, the counter may be made to perform operations at very accurately-spaced time intervals, by feeding from the 50 c/s mains or some other standard frequency source.

**Electronic counter, type N.851.** This is suitable for all applications involving the straightforward recording of counts from the lowest possible speeds up to over 3,000 per sec. It will operate directly from electrical signals of over 3-v. amplitude, or may be employed to count moving articles in conjunction with the Airmec photocell unit, type N.805, and light source unit, type N.806. In the latter case, a count is

recorded each time the light falling on the photocell is interrupted.

The equipment can also be used for measuring the length of material passing a given point, or for totalling the complete length of a large number of short pieces of material such as veneer, metal, plastic, etc. Another use is as a timer or stop-clock by applying the 50-c/s mains or a source of standard frequency to the input. Gating facilities are provided so that the process to be timed may be made to connect and disconnect the input signals automatically and the timing can thus be carried out without introducing inaccuracies due to the operator's judgment.

## Centrifugal separators

The German firm Westfalia Separator A.G. is again to supply the British market, having appointed T. Giusti & Son Ltd., London, as its sales and distribution agents in the U.K.

The post-war range of Westfalia separators reflect the added experience which the designers have acquired both during and since the war years. The range is a wide one—small laboratory models to the largest marine installations.

One of the most interesting models is the LWA-205 multi-purpose laboratory centrifuge. With four interchangeable bowls, the 205 will carry out the functions of solids concentration, liquid clarification and centrifugal mixing.

The makers claim that the greater efficiency of their separators is achieved mainly by their higher speeds of operation (12,000 r.p.m. in the case of the 205). These higher bowl speeds have been brought about by making the bowl itself of high-tensile chrome steel which is lined with stainless steel to combat corrosion.

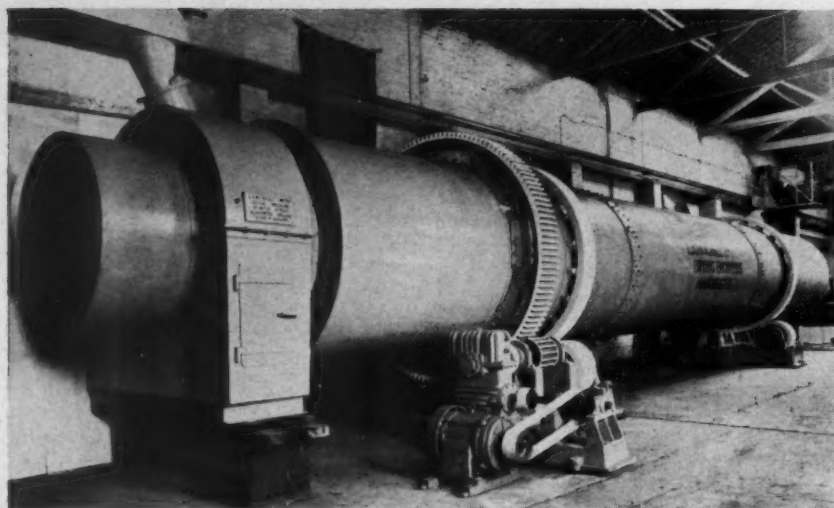
The worm gear drive, too, has been carefully designed and the gears and worms are fitted with replaceable rings, a feature which should result in lower maintenance costs.

## Pumping corrosive fluids

A centrifugal pump which is claimed to have excellent resistance to corrosion has been developed by the Swedish company, Jonkopings Mekaniska Verkstad. The pump has no stuffing box and has a liquid lock wheel with the sealing located entirely on the suction side. The pump is claimed to be absolutely tight and to require no maintenance. It is vertically mounted and designed so that it is possible to dismantle the whole pump without removing the motor or motor stand. The liquid handled by the pump can be used for sealing even if it contains large concentrations or solids—up to 55 to 60%. The makers point out that, since there is no packing to wear the shaft, the corrosion-resistant surface that is sometimes applied to certain materials does not wear out.

The Nobox pump is available in three standard series for varying ranges of





Seen here after erection in the shops of L. A. Mitchell Ltd. is a large rotary drier, the cylinder of which is 8 ft. in diameter by 60 ft. long. The plant was arranged with a rotary cooler 4 ft. in diameter by 30 ft. long. The company specialise in rotary driers and calciners for the chemical and process industries; this particular installation was for a large chemical works abroad.

capacity and head, but each pump is especially designed for its individual requirements, leaving margins for fluctuations in pressure, etc. The pumps can normally be obtained with a seal that is effective up to 24-in. Hg vacuum. They operate with equal reliability at positive pressure and vacuum within very great margins of temperature and pressure. The design features of the pump may be summarised as follows:

The main principle is the replacement of the stuffing box with an auxiliary sealing impeller located in a separate sealing chamber. A liquid ring is produced through the rotation of the impeller, which prevents air from entering the pump and liquid from leaking out. The operation of the hydrodynamic seal is based on a single or double auxiliary chamber-encased impeller. The impeller is placed on a shaft (the pump shaft) and the pipe is fitted on to the pump casing and forms the sealing chamber. If the pump section is under vacuum the liquid in the sealing chamber will have a tendency to be drawn into the pump casing, but will be stopped by the impeller. The sealing liquid in turn prevents air from entering the pump and thus forms an effective seal when the pump is operating under vacuum.

If the pump suction is under a positive head, the liquid will tend to be forced back into the sealing chamber. In the models provided with a double impeller the upper impeller, which is of larger diameter than the lower, will withstand the combined pressure from the positive suction head and the lower impeller. The lower side of the double impeller is made with a ring encircling the vanes. This ring allows the pump to seal against air even if the quantity of the sealing liquid is reduced. The seal operates as long as the bottom surface of the ring is submerged in the sealing fluid. The diaphragm valve is entirely cut off when the pump is in operation, and con-

sequently it does not wear out. Owing to the fact that it need only seal against the pressure from the suction side of the pump, the loss of power in a *Nobox* pump is very small; in certain cases smaller than in conventional pumps.

#### Corrosion-proof motors

A range of squirrel-cage induction motors, designed for use in the corrosive but non-explosive atmospheres found in chemical plants, plating shops, gas works, salt works and oil refineries, incorporates a fan of moulded phenol formaldehyde which is claimed to have withstood severe durability and fatigue tests. The fan is mounted on its shaft by a special method.

Polyvinyl-acetal-covered wire is used for the stator winding. The windings are impregnated with phenolic insulating varnish by dipping and baking them in an automatic heat-controlled oven four times; this process is claimed to produce a finished winding capable of high resistance to corrosive chemicals. The rating plate is made from polyvinyl chloride.

The motors are made to British Standard dimensions and are available for outputs up to 25 h.p. They are similar in appearance to the normal totally-enclosed, fan-cooled machines. The English Electric Co. Ltd. are the makers.

For further information  
about the Plant and  
Equipment described, use  
the coupon on page 262

#### Reflux plunger with automatic water seal

A simple, perfectly hermetic, automatically-acting water seal for reflux condensers or stills which permits an appreciable saving inasmuch as it avoids the need for emery grinding and the wasteful use of cork or rubber stoppers, which are in any case not suitable for all liquids, is described in the French journal, *Chimie & Industrie*, of May 1954, by G. Rey-Coquais.

In the case of a reflux condenser, the part of the reflux entering the neck of the flask is formed as a 'plunger,' leaving a gap of about 1 mm. all round. During the reflux boiling, the condensation of the vapours produces an absolutely tight liquid seal. It is thus possible to boil the most corrosive liquids (mineral acids, caustic alkaline solutions, etc.) without deterioration of the stoppers or wastage caused through grinding.

Similar advantages can be obtained in the case of a distilling apparatus, where a special headpiece can be used to make a water-tight capillary seal with the receptacle as well as with the reflux cooler.

These devices can be used with a wide variety of organic liquids, and experience has shown that they can, in fact, be used even for the most volatile liquids such as carbon bisulphide, acetone, alcohols, ethers, etc. The automatic water seal is useful for many routine operations such as analyses of metals or minerals, saponifications, hydrolyses, acetylations, Soxhlet extractions, nitrations, distillations of pure acids, etc.

The savings are particularly important in the case of two- or three-necked flasks, where each neck can be fitted with a water seal. As there are wide limits of tolerance for the gap between plunger and neck, the parts are interchangeable to a great extent.

#### Flame-retardant insulating sheet

A new flame-retardant, self-extinguishing electrical insulation laminate has been developed by Russell Reinforced Plastics Corp., New York. The material is reported to have retained its self-extinguishing properties even after a test exposure of 90 days to a heat of 275°F.

Known as *Repco* GOC Grade, the laminate incorporates an American Cyanamid Co. polyester resin, *Laminac* 4146, reinforced with Owens-Corning *Fiberglas* Mat. The laminate can be readily punched and machined for specific applications.

In addition to the self-extinguishing property, the new laminate is claimed to have good arc resistance, low water absorption, high dielectric strength, a low dielectric constant, high surface and volume resistivity, high insulation resistance, and low loss and dissipation factors. It is available in a variety of thicknesses and sizes. Because of its close tolerances an entire sheet is usable, thereby cutting down on waste.



# Nitrogen for Explosives and Fertilisers

## NEW AMMONIA, ACID AND AMMONIUM NITRATE PLANTS IN SOUTH AFRICA

TO meet the steadily increasing demand for explosives for South Africa's growing mining industries, particularly for gold, and to provide nitrogen for agricultural purposes, African Explosives and Chemical Industries Ltd. are now building at their Modderfontein factory large-capacity plants for the production of ammonia, nitric acid and ammonium nitrate. Some of the plants are nearing completion. The total installation will cost about £5 million.

Covering about 30 acres, the new plants have been systematically grouped and incorporate modern ideas on general plant layout. Provision has been made for future extensions and a well-planned system of access roads and railway tracks have been laid down.

A modern variant of the Haber-Bosch synthesis method, the ammonia plant will have a rated output of 40,000 tons of ammonia per annum, using as raw materials coke, steam and atmospheric nitrogen.

In the Haber-Bosch process mixed nitrogen and hydrogen gases are made to combine by passing them, under pressure, over a heated catalyst, such as iron and molybdenum, the ammonia formed being condensed by cooling. By making use of the latest type of five-stage compressors the ammonia synthesis plant at Modderfontein has been designed to operate at the unusually high working pressure of 350 atmospheres.

When the plant is in full production approximately 150 tons of coke will be used daily and a system of conveyor belts has been installed to handle it. Arriving from Natal by rail, the coke is emptied by a 'tippler' into large storage bunkers, from which it is belt-conveyed to the crushers and on to the gas producers as required.

Since the gases used in the Haber-Bosch process must be of great purity to avoid inactivating the catalyst, special attention has been paid to purification of the gases. Sulphur removal will be carried out in special gas-tight boxes made of reinforced concrete which are claimed to be among the largest of their kind.

In the gas scrubbing process, which will be carried out under pressure, a system of power recovery will be used whereby the pressure still available in the liquor after scrubbing the gases will be used to drive a turbine or pump, which, in turn, will help to pump the regenerated liquor to the scrubbing towers.

Of special interest are the carbon dioxide removal towers, which are the first of their type ever to be manufactured in South Africa. Because of their size, over 90 ft. high, the towers were made in two sections, which were assembled on site at Modder-



View of synthesis section of new ammonia plant at the Modderfontein factory.

fontein. The thick steel plating used was hand-welded along the inner and circumferential seams, while all outside seams were machine-welded. All stresses were relieved in a special furnace and all the welded joints were x-rayed by the Bureau of Standards. Before being brought finally into use the towers will be tested hydraulically.

All the high-pressure vessels in the ammonia synthesis plant are of the new strip-wound type. These are much lighter than the old type of drop-forged pressure vessel and cost much less.

The liquid ammonia produced at Modderfontein will be stored in three large cylindrical high-pressure tanks and in one low-pressure vessel. In the latter, which will be carefully lagged, the ammonia will be kept at very low temperature. Because of this special mild steel was required in its construction, since ordinary steels would become brittle at the temperatures to be used.

In the nitric acid section two du Pont type pressure oxidation plants, operating at 100 p.s.i., are nearing completion, while a third plant, which will operate at a lower pressure, is being obtained from Holland. Stainless steel is being extensively used in the construction of these plants, which will incorporate the latest power and waste heat recovery units.

The ammonium nitrate produced at Modderfontein will be in prilled form and the plant under construction is designed to produce 200 tons daily. Neutralising vessels will be of the low-pressure type and

concentration of the ammonium nitrate solution will be carried out by the falling film method. All these operations will be controlled automatically by temperature and flow recorders.

Modern mechanical handling methods will be used to deal with the ammonium nitrate in its final form and special methods have been introduced to minimise the handling of bagged ammonium nitrate for use in explosives manufacture.

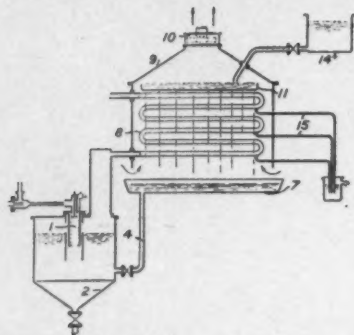
J. GRINDROD

**Oil-gas process.** The *Segas* catalytic oil-gas process is described in a four-page booklet by the Power-Gas Corporation Ltd. This process originated in the laboratories of the former South Metropolitan Gas Co. and Power-Gas are the sole licensee for the commercial development of the process. The process is designed to produce from oil a gas with calorific value, specific gravity and combustion characteristics similar to those of town gas. The gas produced is, in fact, interchangeable with town gas, thus giving the plant wide flexibility either in mixing its output with other gas streams or even replacing them altogether. The plant, too, is capable of cracking the heavier grades of oil and is not limited to the use of highly priced gas oils. The plant consists essentially of a steam preheater, a catalyst chamber and an air preheater. The ancillary equipment includes air blower, oil pump, liquor recirculating pump, secondary oil heater between pump and plant, and instruments.

# British Patent Claims

## Submerged-flame evaporator

Liquids are evaporated in a closed container by means of a submerged flame-burner, the products of combustion and the vaporised liquid are passed through a pipe system over which the liquid-to-be-evaporated is caused to flow, dry air is passed over the liquid flowing over the pipe system, and the partially evaporated



liquid so obtained is then fed to the closed container for further evaporation by the submerged flame burner.

Dilute sulphuric acid flows from vessel 14 into trough 11 and then trickles over serpentine pipe 8 the interior of which is rifled. The combustion gases and steam from container 2 which contains aqueous sulphuric acid heated to boiling by submerged flame burner 1, pass through pipe 8. Air is drawn into the bottom of shell 9 by fan 10 and flows over the acid trickling over pipe 8. The partially concentrated acid collects in tank 7 and then flows into container 2 through pipe 4. The condensate formed in pipe 8 may be blown out of the open end of the pipe by the non-condensable gases, or alternatively, it may be withdrawn through pipes 15.

The burner 1 may be supplied with liquid or gaseous hydrocarbons, and air, or with hydrogen and oxygen. Specification 623,446 is referred to.—658,286, N. Swindin.

## Aluminium and vanadium from chromate solutions

Vanadium and aluminium are removed from solutions containing alkali metal chromates and aluminates and a minor proportion of alkali metal vanadates by adding a lead compound, e.g. the oxide, hydroxide, sulphate, basic sulphate, nitrate, chloride, or acetate, and simultaneously or subsequently bringing the pH to 8-9, to co-precipitate the alumina, and substantially all the vanadate ion and a little of the chromate ion as their lead salts, and removing the precipitate from the solution.

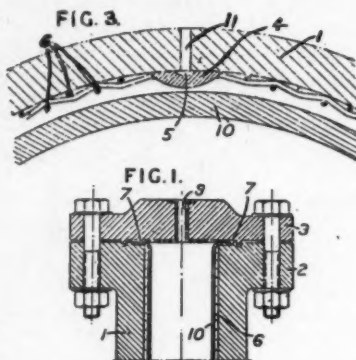
The process finds application in the extraction of chrome ores as disclosed in Specification 661,945, the 'raw liquor' being treated as above described.

The alumina-lead chromate-vanadate precipitate may be discarded, or treated with sulphuric acid to produce lead sulphate and an impure aluminium sulphate solution. Alternatively, it may be dissolved in 50% caustic soda solution, and treated with sodium, calcium, barium, etc., or hydrogen sulphide to reduce the chromate and to precipitate lead sulphide. The vanadium-containing sodium aluminate solution is purified by treatment with barium halide (chloride) or sulphate or hydroxide to precipitate a barium vanadium complex.

The chromic hydroxide-lead sulphide precipitate from the previous operation is treated with sulphuric acid to produce lead sulphate and hydrogen sulphide for reuse, and chromic sulphate solution.—661,946, Diamond Alkali Co.

## Autoclave

An autoclave comprising an outer shell 1 with a deformable liner 10 of metal or plastic corrosion-resistant material has spacing means 4, 6 between the shell and the liner and vents 11 provided through the shell near the spacing means for the escape



of trapped fluid when the liner is expanded against the outer shell by internal pressure.

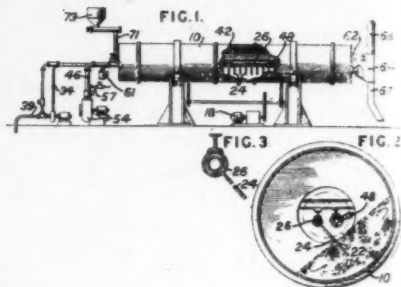
The vents further serve as a means of detecting a leakage in the liner.

In a lead-lined container the spacing means may comprise tack-welded half-round ribs 4 with channels 5 in communication with the vents 11 and a wire mesh 6 tack-welded intermediate of the ribs, but either the ribs 4 or the wire mesh 6 may be omitted. The ends of the liner 10 are folded down and augmented by molten lead in flanges 2 on the ends of the vessel. The vents 11 may be replaced by grooves in the end faces of the shell under the lined end cap 3.

The autoclave with a lead liner is particularly suitable for the synthetic manufacture of urea from carbonic acid gas and ammonia.—656,793, *Compagnie de Produits Chimiques et Electro-Metallurgiques Alais, Froges & Camargue*.

## Drying and pelleting process

Solutions of solids are dried to give uniform pellets by introducing the solution directly into the interior of a heated, agitated bed of particles established in a cylinder rotating about its longitudinal axis which is disposed approximately horizontal; the operating conditions, and particularly the temperature of the bed and the depth at which the solution is introduced below the surface of the bed, being adjusted so that the peripheral particles



are maintained in a dry state. The process is particularly applicable to the drying of an aqueous solution of calcium chloride, and also to solutions of magnesium chloride, sodium phosphate, and sodium silicate.

A kiln 18 containing a bed 22 of calcium chloride pellets, is rotated, via a chain and sprockets, by motor 18. The bed is heated to 400°F. by a series of burners 48 supplied with a mixture of gas and air through conduit 46. The burners are disposed at an angle of about 20° with the surface of the bed so that the flames do not actually contact it.

A solution containing approximately 55% by weight of calcium chloride is pumped through pipes 39 and 34 into main feed-pipe 26, and it is then distributed through a series of pipes 24 into the interior of the bed; the points of introduction below the surface of the bed being between 10 to 45% of the depth of the bed. The kiln discharges the product (pellets having an average diameter between 1/4 in. and 3/8 in. and a density between 1.32 and 1.64 g./ml. respectively) through cylinder 62 into chamber 64 and chute 67; while combustion gases are discharged through flue 68. Fresh bed particles may be supplied to the kiln from hopper 73 through chute 71.

The process may be employed to convert material made up of irregular particles of mixed sizes into nearly uniform pellets by dissolving a portion only of the original material in a solvent, feeding the resulting solution to the drying apparatus while at the same time also feeding the remaining portion of the material as solid particles.—670,083, *Morton Salt Co.*



# World News

## GREAT BRITAIN

### Difficulties of building new rayon plants in the U.K.

*'It is becoming increasingly difficult to find in the United Kingdom facilities which are requisite for such plant, and which include amongst other things an adequate supply of the right quality of water.'* This significant comment was made by Sir John Hanbury-Williams, chairman of Courtaulds Ltd., in his annual review for 1953-54. The plant he was referring to is one for the manufacture of viscose rayon stable fibre which Courtaulds are to build on the outskirts of Grimsby. The plant will have an ultimate capacity of 100 million lb. p.a. and it is scheduled to be in operation in 1957.

A review of the affairs of Courtaulds' various subsidiary and associated companies included mention of the following:

**Cellophane.** The capacity of the Bridgewater factory of British Cellophane Ltd. is being considerably enlarged.

**Canada—viscose film.** T.C.F. of Canada Ltd. completed the erection of their plant for the production of transparent viscose film at Cornwall, Ontario, last autumn, production having started in July 1953.

**Pulp production.** The company are associated with Snia Viscosa, together with the Industrial Development Corporation of South Africa Ltd., in the South African Industrial Cellulose Corporation (Pty.) Ltd., which is to engage in the production of wood pulp from the Eucalyptus Saligna. Construction of this company's rayon pulp plant near Durban is proceeding.

Discussing the international textile situation, Sir John Hanbury-Williams said that total world textile production in 1953 recovered from the setback of the previous year, and whilst rayon and other man-made fibres shared fully in this general improvement there were marked differences between the various producing countries. The production of all man-made fibres was 16% higher than in 1952; output of rayon increased relatively to the same extent as that of the new synthetics, the production of which thus remained at about 7% of the total. In Europe the output of man-made fibres recovered from the recession of 1952 and in some cases now surpasses previous post-war peak levels.

### New gas grid will be first to handle colliery methane

The first gas grid in the British Isles to handle colliery methane reformed to be interchangeable with coal gas is being built by the Wales Gas Board. This grid, with its 130 miles of high-pressure pipeline, will save Britain 76,000 tons p.a. of coal. It will extend from Llangollen through Wrexham to Connah's Quay and along the North Wales coast as far as Carnarvon, with a branch over the Menai Straits to Anglesey.

Gas will be supplied to some 25 gas undertakings.

Gas will be collected by this grid from three sources: the new Maelor gasworks of the Wales Gas Board; the coke ovens of John Summers & Co., Shotton, near Chester; and the Point-of-Air colliery, from which the methane is being drained.

Another unique feature of the grid is that it will be the first gas grid constructed in the British Isles using the modern pipeline methods so successfully developed and used in America. These have now been specially modified to meet the conditions of ground and countryside in North Wales.

### Bronze rod development

A secret process developed at the new bronze foundry at the Sutton-in-Ashfield, Notts, works of Sheepbridge Alloy Castings Ltd. (formerly titled Sheepbridge Steel Castings Ltd.) has led, the company claims, to the production on a very competitive basis of phosphor-bronze chill-cast rod or 'stick' of a refined and guaranteed quality never before made available to industry by British commercial metallurgy. The bronze rod, *Solicast*, is suitable for making components such as bushes, bearings, gear blanks, sleeves, etc., for the motor and allied industries.

It is claimed that, unlike bronze rod made by other methods, it is not liable to contain hidden flaws and defects, such as porosity, hard spots, cold laps, gas holes and foreign inclusions. It is pointed out that often these flaws and defects in the bar material come to light only when components are being machined and cause the component made from the faulty material to be scrapped.

### Chemical plant's safety record

Employees at the Newport, Mon., factory of Monsanto Chemicals Ltd. recently completed 2 million man-hours of work without a single lost-time accident. The factory, which employs approximately 1,000 men and women on the production of industrial chemicals and plastics, commenced its as yet unbroken accident-free run on July 10, 1953.

In 1952-53 the same factory achieved a total of 1,425,860 man-hours without a lost-time accident, but the present achievement sets up a new record for Monsanto in Great Britain.

### Manganese ore from Russia

In the 12 months June 1953 to May 1954 93,000 tons of manganese ore valued at £1,688,000 were imported from the Soviet Union. There were no imports from the Soviet Union in the previous 12 months.

### Change of address

The Junior Institution of Engineers is now at 14 Rochester Row, Westminster, London, S.W.1 (telephone: Victoria 0786).

### New oil additives factory

The Distillers Co. Ltd. and the Oronite Chemical Co. of San Francisco, U.S.A., announce the formation of Orobis Ltd., a jointly owned company, now constructing a plant for the manufacture of lubricating oil additives at Hull.

A complete range of lubricating oil additives, as manufactured by Oronite in the United States, will be manufactured and marketed by the new company. Facilities will include a fully equipped engine-testing and customer service laboratory. It is expected that the plant will be in operation early next year.

### Morgan Crucible's £2½ million expansion nears completion

The near completion of a five-year programme which has involved total capital expenditure of over £2½ million was referred to by Mr. P. Lindsay, O.B.E., M.C., chairman of the Morgan Crucible Co. Ltd., in his annual statement. Speaking of productivity and human relations, Mr. Lindsay said he did not subscribe to the popular conception that the further advance in industrial efficiency necessary to national solvency 'all depends on management.' There needs to be, in addition, a more enthusiastic approach to the task, inside and outside industry. The war-time slogan 'It all depends on me' is more appropriate.

### Natural gas struck in Sussex

A small quantity of natural gas at a low pressure was found at Crowborough Warren, Sussex, on June 23, where the Gas Council's first deep drilling operation is taking place. This is the first definite result in the search for natural gas which started six months ago and is to be spread over the next five years at a cost of £1 million. Drilling at Crowborough is being done for the Gas Council by the D'Arcy Exploration Co., a subsidiary of the Anglo-Iranian Oil Co., as natural gas is often found in the neighbourhood of oil and the drilling is the same. Before gas was found on June 23 at over 800 ft., drilling had been in progress for five weeks. This low-pressure gas was only a small amount trapped in the pores of the Purbeck limestone interval, through which they were then boring. The rate of drilling is approximately 2 ft. an hour, at a cost of anything from £2 to £10 a foot. Sample cores of rock are taken every 5 ft. and tested for porosity in a nearby mobile laboratory, as gas is found in the pores in the rock. Drilling is kept up continuously and the men work 12-hr. shifts. It is not expected to reach the reservoir of natural gas, if it exists, before at least 1,000 ft., and the Gas Council are prepared to go down to the Corralion level at 2,150 ft.

Earlier this year it was reported that drilling was taking place at Cousland in Scotland, also carried out by the D'Arcy Exploration Co., where natural gas had been discovered in 1938, though not exploited commercially. Drilling there had not proved successful and preliminary sur-



vey work indicated that Crowborough, which is situated on the crestal portion of an anticline, was a likely place for natural gas to occur. It was known, too, that supplies of natural gas exist in this part of Sussex. For instance, the nearby railway station at Heathfield was lit for many years by natural gas.

It is not only the expensiveness of coal, now costing about £25 million a year more than it did when the industry was nationalised in 1949, which makes it desirable to find an alternative source of gas. As Sir Harold Smith, chairman of the Gas Council, has pointed out, two other factors need to be taken into consideration. These are, first, the increasing scarcity of good carbonising coal and, second, the threat to the gas industry from electricity produced by atomic energy. However, natural gas needs to be available at a rate of 1 to 2 million cu. ft./day before it becomes an economic proposition, even though it has twice the calorific value of ordinary gas-works gas.

#### Whessoe's successful year

Under a licence arrangement with the North Thames Gas Board, Whessoe Ltd. are to build plants, to the former's patents, for the removal of organic sulphur from town gas. This was one of the new orders referred to in the chairman's review of the company's activities during the past year.

He also referred to the fact that the company is constructing for the atomic power station at Calder Hall, Cumberland, the two main reactor vessels, following the preparatory design study which the company were commissioned to make by the Department of Atomic Energy. More recently the company were commissioned to make a second design study for the 'sealed building' to contain a new atomic pile at Harwell and they have now received the order for construction.

**Greater fabricating capacity.** Three factors have contributed to the good results of the year. First, the completion of the reconstruction of the main block of production shops has led to a greater fabricating capacity, even though the company cannot reap full benefit until the final stage of the reconstruction scheme has been completed. Second, an increase in steel supplies, although the supply of plate is still barely adequate. Third, Whessoe have been able to accept orders over and above works capacity by obtaining sub-contracting assistance. In the result, the total output for the year has amounted to 52,000 tons, compared with 43,000 in the previous year. Of the total sales corresponding to this tonnage, 45% has gone for export.

The petroleum industry has continued to be the principal customer for large tonnages. For the gas and coking industries, the company's production has been running at a higher level than ever before.

**Reconstruction.** The completion of the main production shops was mentioned earlier; the company are now engaged on

### The Leonard Hill Technical Group—August

**Corrosion Technology**—Corrosive Nature of Combustion Gases; Corrosion-Resistant Paint for Outdoor Structures; Corrosion in the Motor Car, 1; Corrosive Wear of Piston Rings; Corrosion Inhibitors, 1; Petroleum-Based Corrosion Preventives; Fretting Corrosion.

**Manufacturing Chemist**—Extraction of Animal Products; Organic Micro-analysis, 2; Estimation of Volatile Acids in Cough Mixtures; The Vitamins, 1; Marchon Products' Factory; Progress Reports: Disinfectants, and Pest Control Chemicals.

**Paint Manufacture**—Thermal Radiations and Paint Films; Conophor Oil; A History of Paints and Varnishes in Great Britain, 5; Carbon Blacks for Protective Coatings, 3.

**Food Manufacture**—Kenya Meat Commission Factory at Athi River, Nairobi; Standards for Quick Frozen Foods; The Manufacture of Cucumber Products in Sweden.

**Fibres (Natural and Synthetic)**—Fast-to-Gas Fading Acetate Rayon Dyes; Phototropic Dyes; Influence of the Dyeing Method on Wool Wearing Properties; The Dyeing of Dynel.

**Petroleum**—Trends in Modern Viscometry, 3; Azeotropic and Extractive Distillation, 1; Gamma-Radiography in Oil Storage Installations, 1; Petroleum Additives.

**Building Materials Digest**—Preserving Timber: The Use of Water-Soluble Chemicals; Prestressed Concrete System Used in Worthing Technical School; Stone for the Rebuilding of Cities—Slate.

**Muck Shifter**—The St. Lawrence Seaway Project; Inauguration of 285,000-kw. Swedisch Power Station; Memory Lane—Reminiscences.

**Atomics**—Scintillation Detectors in Medical and Biological Research; The Use of Halogen-quenched Geiger-Muller Counters with Queuching Probes; A New Mobile Weld-testing Service; Scientific Research in the U.K., 1952-53.

the final stage dealing with pickling and dispatch. Whessoe's chairman recalled that the company were the first in the U.K. to apply phosphoric acid pickling to heavy steelwork; the new and larger pickling shop incorporates experience gained in the pickling of some 500,000 tons of steel plate and sections since then. This final stage also includes the provision of an overhead gantry for the dispatch of finished materials, and major improvements in the rail and yard layout of the whole northern area of the works.

Since reconstruction was started in 1946 the company have expended approximately £1 million on it and on the provision of new machine tools and equipment.

**Increasing competition.** Dealing with future prospects, the chairman struck a note of caution by referring to increasingly keen competition for a smaller market demand, particularly in the case of the petroleum industry, which has virtually overtaken its heavy capital construction programmes.

#### Practical x-ray crystallography

A course intended for graduates and others suitably qualified who require practical experience in x-ray crystallography will be held in the Physics Department of Battersea Polytechnic, commencing September 28, 1954. The course will consist of lectures, demonstrations and practical work, lasting altogether about 54 hr.

The course will include the operation of gas and vacuum x-ray equipment, use of standard x-ray cameras, single crystal, powder and back reflection methods, and interpretation of photographs. The fee is £2 5s.

#### World's largest aluminium drawn tubes

A mechanical drawbench which has just been installed in the Kitts Green, Birmingham, works of James Booth & Co. Ltd., is believed to be capable of drawing the world's largest diameter aluminium-alloy tubes. When the drawbench and ancillary equipment are producing to maximum capacity it is expected that tubes with outside diameters of up to 17 in. will be possible. At the moment, however, production is being started up on smaller sizes.

It is hoped, eventually, to produce the large tubes in lengths up to 35 ft., but for tubes with a thick wall the length may be limited by the maximum weight. At present this limit is approximately 300 lb.

This new development will open up an entirely new field for strong, light, aluminium-alloy drawn tubes and it is of interest that in 1937 the same company also installed the first 12,000-ton forging press in this country—it is still the largest—and was one of the first to install a 5,000-ton extrusion press.

The new drawbench was supplied by Sir James Farmer Norton & Co. Ltd.

#### Obituary

We record with regret the death of Mr. Hugh Griffiths, B.Sc., A.R.C.S., F.R.I.C., president of the Institution of Chemical Engineers in 1945 and 1946. He was a consulting chemical engineer and did much work on the application of high vacuum technique and on crystallisation. From 1917 to 1932 he was lecturer in chemical engineering at Battersea Polytechnic. In 1932 he joined the board of British Carbo-Union Ltd. and devoted much energy to the building of installations for the recovery of solvents and the extraction of benzole by adsorption processes.

#### VENEZUELA

#### Soda factory planned

It has been stated in the local press that the Venezuelan Development Corporation (C.V.F.) are to equip a factory capable of producing 2,000 metric tons of chlorine and 2,300 tons of caustic soda. This would appear to offer opportunities to United Kingdom manufacturers of machinery suitable for this industry.

## INDIA

### Dyestuffs manufacture in India

Mr. Kasturbhai Lalbhai, chairman of Atul Products, and Imperial Chemical Industries have reached agreement for the manufacture of selected vat dyestuffs and intermediates by a new company in which I.C.I. (India) and Atul Products will be equal partners. The authorised capital will be Rs. 5 crores (about £3,750,000). The plant will be erected on the site of Atul Products at Bulsar and full technical information will be furnished by I.C.I. The project has been given the approval of the Indian Government and erection of the factory will start at an early date.

### Coke-oven plant

The West Bengal Government has submitted to the Planning Commission of the Union Government a 90-million rupees combined scheme for the establishment of a coke-oven plant at Durgapur in Burdwan district.

At a later stage the question of bringing coke-oven gas from Durgapur to Calcutta by means of pressure pipes may be considered.

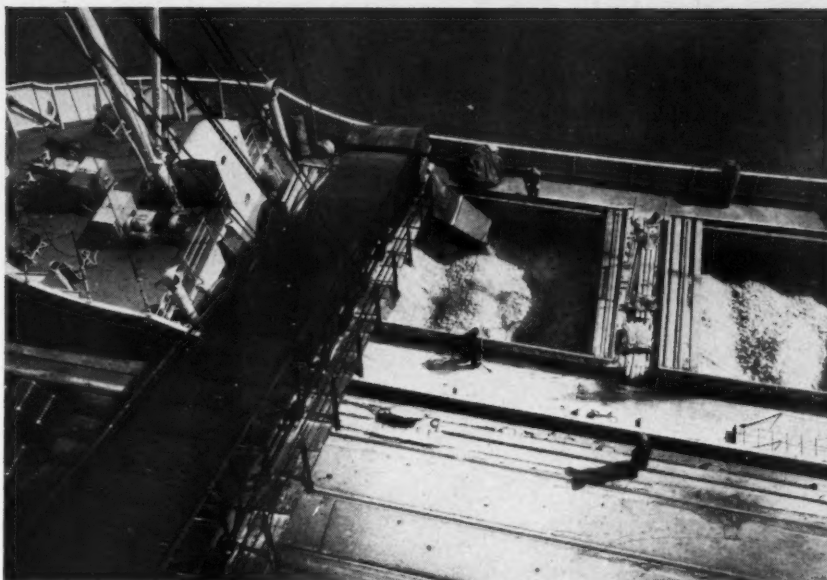
## BRAZIL

### Priority investments

The Brazilian Government has published a list of economic activities where capital investments will be considered of vital interest to the country. Foreign investments in these branches of industry will enjoy repatriation and transfer rights under official currency rates and eventually other privileges such as exemption from import duties for equipment, taxes, etc., to be decided in each instance by the Federal Commission for Industrial Development.

The list approved is as follows:

- (1) Basic industries and services such as production of electric power, transportation and communications services.
- (2) Refrigeration and storage plants.
- (3) Manufacturing of machinery, equipment or parts for the production and distribution of electric power, transport and communications.
- (4) Colonisation and settlement, farming, vegetable extraction, or technical assistance to such activities.
- (5) Food processing.
- (6) Production of essential medicaments.
- (7) Education and technical research for training workers and technicians in Brazil, and research on new work methods.
- (8) Manufacture of machinery, equipment and fertilisers for farmers, or equipment for irrigation and meat refrigeration.
- (9) Other basic industries comprising:
  - (a) Production, processing or industrialisation of fuel;
  - (b) Mining and processing of ores;
  - (c) Basic metallurgy, such as furnaces, and processing plants for non-ferrous



### RECORD SHIPMENT OF SODIUM SILICATE

The Warrington soap and chemical firm of Joseph Crosfield & Sons Ltd., who are the largest manufacturers of sodium and potassium silicate in the U.K., recently completed dispatch of the biggest single consignment of sodium silicate ever shipped overseas from the U.K. Seven hundred and fifty metric tons of sodium silicate glass, representing a week's output from one of the Crosfield silicate furnaces, were loaded into 61 rail wagons at Warrington and sent forward by special train to the Manchester Ship Canal Co. docks at Ellesmere Port. Standing by at the docks ready to receive the cargo was the M.V. 'Ingrid,' a Swedish coaster on her maiden overseas voyage, which had been specially chartered by the customer. Loading of the consignment was completed without incident in 4 hr.

ores, etc.; (d) Metallurgy for transformation of metals to produce rolled iron, rolled steel, alloys, etc.; (e) Basic chemical industries such as sulphur, acids, fertilisers, cellulose, paper, portland cement, synthetic rubber, etc.

- (10) Mechanical industries and industries of essential electrical material, comprising production of industrial machinery for heavy industries and mining.
- (11) Production and processing goods for export.
- (12) Prospecting of mineral ores and surveying for other natural resources.

## COLOMBIA

### Industrial projects

The Industrial Development Institute has engaged two French technicians to investigate the possibility of establishing a paper factory in Colombia. The Mexican Compania Industrial de San Cristobal is also investigating a similar project, intended to produce newsprint from bagasse. The Swedish firm, Ahlen and Arkelund, has also initiated activities in Colombia through a subsidiary established in Medellin.

A French company reported to be successfully manufacturing pharmaceutical products in Mexico has been negotiating

with the Chamber of Commerce of Bogota for the establishment of similar manufactures in Colombia.

The French firm, Etablissements Chelle, is to supply a bottle washing and filling plant for the new liquor factory of Cucuta.

## TURKEY

### Cement projects

The Turkish government has awarded contracts for four cement factories to the French concern Fives-Lille. One will have an output capacity of 450 tons daily. Production capacity of the other three will be 250 tons/day. Delivery is to begin at the end of this year.

## SOUTH AFRICA

### Sulphuric acid plant for uranium producers

A large contact plant for the production of sulphuric acid is to be erected by the Stilfontein Gold Mining Co. Ltd. for use by itself and other uranium producers. The cost of the plant, which is estimated to be £750,000, will be financed by loan funds made available to the company from American and British sources on the same terms as those advanced to the uranium producers. This contact acid plant is additional to the small auto-oxidation acid production plant which supplies only a portion of the company's own sulphuric acid requirements.



The company's production of uranium commenced in the last quarter of 1953. Extensions to the uranium plant to treat slimes from the Ellaton, New Klerksdorp Gold Estates, Babroscro and Afrikander Lease Mines, all of which are in the vicinity of Stilfontein, are progressing satisfactorily and should be completed early in the second half of this year.

#### PORTUGAL

##### Paper and pulp industry

On a recent visit to the Cacia mill of the Companhia Portuguesa de Celulose the Minister of Economy referred to the country's need of more newsprint, wood pulp, etc., at prices comparable with that imported (imports of paper and wood pulp are about 30,000 tons p.a., valued at 180 million escudos). The schemes under way would ensure local production of 16,000 tons of crude pulp, 8,000 tons of bleached pulp and 8,000 tons of paper (mainly Kraft).

The Cacia mill, which already employs over 500 workmen, has cost 335 million escudos (234 million on equipment), but the value of its annual production is estimated at 106 million escudos, which should rise to 135 million when the second phase of construction is completed. Sixty million escudos' worth of orders for its exportable products are stated to have been secured in Europe. The first annual report has appeared of the company Celuloses de Guadiana, S.A.R.L., whose formation was reported in the Economic Report for April 1953, and which plans to produce pulp and cardboard from straw in a mill in the Alentejo province. The report states that a site has been acquired and is being levelled, and that the necessary machinery has all been acquired in England and is mostly ready for shipment.

##### Market for fan equipment

Some notes on the market for fans and ancillary equipment in Portugal which have been compiled by the Export Services Branch of the Board of Trade should be useful to British manufacturers. It is pointed out that Portugal can by no means be considered as a highly industrialised country. The present position as regards types of plant in which fans are employed is as follows:

**Mechanical draught.** This is employed in a few instances for stationary boilers, where for some reason sufficient natural draught cannot be obtained, or where very low-grade Portuguese coal has to be consumed. In the case of marine boilers the forced-draught equipment is usually imported with the boilers themselves.

There is a certain demand for small fans for forges, oil burners, etc., and there is also a moderate number of cupola furnaces for which high-pressure fans are required.

**Dust-collecting plant** is employed by the country's three cement factories and to a very limited extent in other industries, such as cork and fertiliser factories, rice mills,

metal polishing and grinding shops, etc.

**Local production.** One or two engineering firms in the north of Portugal produce a certain quantity of small blower fans for forges and there are engineering firms who occasionally manufacture fans for special installations, but there are only two firms, both in Lisbon, who are more or less regularly engaged in the manufacture of fans and ancillary equipment.

One of these has a fair-sized factory in which, however, not only fans are manufactured, but also central heating installations. Centrifugal, multi-blade and propeller fans are produced.

The other firm has only a small work shop and produces chiefly centrifugal and multi-blade fans.

So far as can be ascertained, no axial-flow or cast-iron fans, other than the small models for forges, are manufactured locally.

#### SPAIN

##### Metallurgical cement factory

Over half the installations at a new metallurgical cement factory in Barros, Asturias, are now in operation following the ignition of a new Buhler vertical kiln. The factory has been built for the Sociedad Metallurgica Duro-Felguera, one of Spain's largest iron and steel producers. Duro-Felguera state that when operations are

## ★ PERSONAL PARAGRAPHS ★

University. He was for eight years from 1936 engaged in research at the Royal Aircraft Establishment, Farnborough, on materials for use in aircraft. After two years in industry as a metallurgist and research and development manager he joined in 1949 the Chief Scientific Adviser's Division of the Ministry of Works, where he remained until transferred to the Building Research Station, D.S.I.R., in 1950. He has also served on various technical committees of the British Standards Institution and on advisory committees of the Ministry of Supply.

Research at the Laboratory covers many branches of physics, engineering and metallurgy and special investigations of a varied character are made for firms and other bodies, normally at the Laboratory, but where appropriate on site.

★ **Mr. J. T. Procter** has been elected president of the Fertiliser Society and Dr. **R. Stewart** has been elected vice-president. **Mr. C. T. Ward**, **Mr. R. G. Warren** and **Mr. R. A. Webb** were elected to fill vacancies on the Council.

★ **Mr. J. C. Duckworth**, chief engineer of the Ferranti laboratories, Wythenshawe, Manchester, has been appointed by the British Electricity Authority as nuclear power engineer. Mr. Duckworth will organise and lead a new branch of the chief engineer's department, which will be engaged on design, construction, and operation of nuclear power stations.

fully under way—probably in two or three months' time—the new works will be producing at the rate of 54,000 tons annually.

#### BURMA

##### Industrial projects

Last month (p. 195) we reported on Burma's industrial development plans and pointed out that there are export opportunities in Burma for British chemical and chemical engineering firms. Because a number of firms have asked the Board of Trade how they could bring their interest in the various projects to the notice of the Burmese Government, a list of the appropriate Burmese authorities has been issued. While a representative on the spot is always advisable, firms who are interested in the projects we mentioned last month can write to the following:

The Secretary,  
Ministry for Industry,  
Government of the Union of Burma,  
Secretariat, Rangoon.

The Secretary,  
Economic and Social Board,  
Promote Court, Rangoon.

The Secretary,  
Ministry of National Planning,  
44 Signal Pagoda Road,  
Rangoon.





Seen here at the opening of Marchon Products' new fatty alcohols factory, on which we comment elsewhere in this issue, are Sir Henry Tizard, F.R.S. (left), who was formerly chairman of the Advisory Council on Scientific Policy and Defence Research and is now a Treasury-nominated director of Marchon's associated company, Solway Chemicals Ltd.; Lord Adams (centre), a director of the West Cumberland Industrial Development Co; and Mr. F. Schon, chairman of Marchon.

## JAPAN

### Foreign technical aid wanted

The thirteenth edition of the booklet 'Techniques Japan Desires to Import' has been issued by the Foreign Capital Research Society of the Bank of Japan, Tokyo.

This booklet, which supersedes the twelfth announcement of desired technological assistance of June 1953, lists categories of technology for which foreign assistance or participation is desired, including the following industries: textile, chemical, petroleum, ceramic, metal, machinery, aircraft, electrical machinery, pharmaceutical, and civil engineering.

### Higher sulphate of ammonia output

Production of sulphate of ammonia in Japan is expected to reach 2,600,000 tons in the year 1954-55, a considerable increase over the estimated output of 2,350,000 tons in the year ending July 31, 1954. Exports during the year 1953-54 are estimated at 450,000 tons and it is hoped that in the following year about 640,000 tons will be sent abroad.

Meanwhile, Japan hopes to sell 250,000 tons of ammonium sulphate to Nationalist China during the year ending July 31, 1955—about the same amount as in the previous 12-month period, according to the Japan Ammonium Sulphate Industry Association. Two Japanese business men have flown to Taipei to negotiate with officials of the Nationalist Government concerning the price to be paid.

In the past Japan has sold the chemical to Nationalist China at \$56.80 per ton—less than the price to domestic consumers. In April, however, Japan exported 5,000 tons to Communist China at a price of \$62.30 per ton (the first shipment to that destina-

tion since ammonium sulphate was taken off the contraband list last September). Now the Japanese are said to be anxious to realise at least \$60 per ton for future exports, while Nationalist China hopes to import at the previous price.

## UNITED STATES

### More competition in the chemical industry

The U.S. chemical industry is now in a period of continued expansion, slightly rising business activity, and intensified competition. This is indicated by mid-year Government and business statistics. During the 12 months up to mid-1954 there have been some segments of the industry showing declines in sales of as much as 10%. However, according to the Federal Reserve Board Index, overall activity in chemicals and allied trades dropped only 0.7 from March 1953 to March 1954. The F.R.B. Index for all business dropped 9 points in the same period.

For the industry as a whole, sales for the first quarter of 1954 were almost 99% of sales for the same period in 1953, while sales for all manufacturing stood at about 95% of sales in the first quarter of 1953.

While not on the same statistical basis, a Manufacturing Chemists' Association survey of first-quarter reports by 39 chemical manufacturers, representing a majority of U.S. chemical production, shows that their net profits were 5% above those for the first quarter of 1953.

There has been some speculation that over-expansion has resulted from the chemical industry's investment of more than \$10 billion in new plants and equipment since 1945, including the record \$1.6 billion in 1953.

There are a few product groups in which

present production capacity does exceed current demand. But over all, chemical manufacturers will spend between \$1.3 and \$1.4 billion during 1954 on new plants and equipment and the industry is now forecasting that sales and production in 1975 will be about 400% of sales in 1950.

### Magnesium metal in sheet form

A large magnesium fabricating plant recently opened by the Dow Chemical Co. at Madison, Illinois, is claimed to be the first in the world for the production of magnesium metal by mass production.

The new plant will turn out the metal in sheet form, in contrast to existing practice in America which involves casting in ingot form. The Madison plant has a capacity of about 16 million lb. p.a. of sheet magnesium. Its eventual potential is said to be 100 million lb. p.a., equivalent to total annual U.S. ingot output in the recent past.

Dow expects that the availability of the metal in quantity in sheet form will open up new markets for magnesium. The company has been working on magnesium since shortly after World War I, but in the past has not been able to turn it out cheaply enough because the ore is never found in pure form, and is difficult to separate from various chemical combinations in which it is found.

## GERMANY

### Enquiry into synthetic rubber production

Following the postponement, on economic grounds, of the plan to set up a plant for the manufacture of 30,000 tons of synthetic rubber from French alcohol imported at a reduced price, the West German Economics Ministry has ordered tests to ascertain the economic value of the new German processes for making synthetic rubber. The tests are being carried out at the Huels chemical works. The alternatives preferred at the moment are either to process 50,000 tons of butane a year, to be bought from the United States, or to process 190,000 tons of crude oil a year into butadiene, the raw material for buna. Coal, the main raw material now used, is considered too expensive.

Huels is the sole German producer of buna. Its production is about 300 tons a month. The occupation powers were permitted production of up to 500 tons a month.

## TUNISIA

### Cement surplus

Since the Compagnie des Ciments Portland de Bizerte went into production in August 1953 Tunisia now produces more cement than she can consume and is urgently seeking outside markets. For various reasons outlets in Libya and Algeria have not proved so promising as was hoped and after six months of production the Bizerta company was obliged to close down its furnace.

## Export Opportunities

### Oils, fats and TIO

Bethold Pahlow, Hamburg 39, Hainbuchenweg 5, a commission agent, has advised the British Consulate-General, Hamburg, that he wishes to represent a U.K. firm which could supply raw materials such as crude oils and fats for the soap, margarine and paint industry. He is particularly interested in importing titanium dioxide.

### Paint-making machinery and materials

The Colombian firm, Idepym Ltda., Calle 15 No. 19-A-01, Bogota, Colombia, would like to be put in touch with U.K. manufacturers of ball and pebble mills, roller mills, mixers, titanium dioxide, materials for rubber-base paints and makers of pigments.

The Bogota firm are paint manufacturers who are planning to expand their production in existing lines (one of which is manufactured under licence from the United States) and in new lines and are, therefore, interested in any new paint developments which can be offered by U.K. firms.

Manufacturers interested in this enquiry should communicate with Idepym Ltda. direct by airmail, giving full details of the products offered. Prices should be quoted in U.S. dollars c.i.f. Reference ESB/16213/54 should be quoted in any correspondence to the Board of Trade about this notice.

### Recovered and residue oils, and off-fats

Otto Asbach & Co., Chilehaus B, Hamburg 1, an old-established firm of importers, have informed the British Consulate-General, Hamburg, that they wish to contact U.K. exporters of recovered and residue oils (vegetable and animal) and of off-fats.

Otto Asbach & Co. are importers and exporters of oils, fats, waxes, oil seeds, etc., buying on their own account.

Firms interested in this enquiry are asked to write direct to the Hamburg firm, giving details of prices, deliveries and terms, etc. (Board of Trade reference: ESB/15475/54).

### Plastic raw materials

Malmsten & Bergvall, P.O. Box 48, Gothenburg 1, Sweden, wish to act as agents for a United Kingdom manufacturer of plastic raw materials. The Swedish company are an old established firm of chemical wholesalers. They claim to have a selling organisation covering the whole of Sweden by means of 12 travellers or salesmen and they correspond in English. They wish to work on a commission basis and sell to both wholesalers and retailers.

### Basic and intermediate chemicals

Mr. Charles K. Cosse, of the Kingston Chemical Co. Inc., 15-21 William Street, New York 5, N.Y., has informed the British Consulate-General at New York that his company is interested in importing from the U.K., on its own account and not as agents, the following chemicals: hot pressed crude naphthalene, cobalt oxide, cobalt sulphate, quinine, quinidine, caffeine, theobromine, digitoxin, ephedrine sulphate and ephedrine hydrochloride.

The company purchase basic chemicals and intermediates for further processing. They have no manufacturing facilities of their own and their processing is done on a contract basis by some of the larger American chemical manufacturers such as du Pont, Monsanto, Rohm & Haas, etc.

Mr. Cosse said that the list of chemicals given above was not exhaustive.

Manufacturers interested in this enquiry are requested to write direct, by airmail, to Mr. Cosse, forwarding all available catalogues, illustrations and quotations in dollars c.i.f. It would be appreciated if they would send copies of the initial correspondence to the British Consulate-General,

61st Floor, Empire State Building, 350 Fifth Avenue, New York 1, so that the enquiry may be pursued (Board of Trade reference: ESB/15092/54).

For further details of these enquiries, write to the Export Services Branch of the Board of Trade, Lacon House, Theobalds Road, London, W.C.1.

### Diffusion-distillation Separation of Isotopes

The feasibility of separating isotopes by diffusion through an inert gas barrier is discussed by O. W. Williamson in report SO-3252 of the U.S. Atomic Energy Commission. The optimum operating conditions for a multistage cascade counterflow system as determined in the study reported are described. The theoretical discussion includes methods of calculating mutual diffusion coefficients, for binary systems, an approximate method for a ternary gas system and a method of estimating the efficiency of a barrier vapour. The effect of the several variables on the operation of a system are discussed. A comparison is made of four methods of gaseous diffusion for isotope separation.

### Stress Distribution in Welded Pressure Vessels

(Concluded from page 251)

More recently a Werner & Pfleiderer pulsating pressure plant was commissioned in the research station. This equipment is capable of testing a vessel between any lower and upper pressure up to a maximum of 4,500 p.s.i. at frequencies up to 100 cycles/min., although the frequency is reduced for large vessels, which take considerable quantities of water at each application.

The use of this form of test, while expensive, is tending to replace some of the strain gauge testing, as the results are produced more quickly and directly.

### Conclusion

The designer will not be able to avoid stress raisers entirely, but he can make sure they do not multiply each other by being coincident.

The greatest single difficulty in assessing the results of tests of materials and designs is to judge the effect of service time; all other factors can be evaluated, either analytically or experimentally. For this reason investigators in this field are in great need of authoritative case histories of plant which has operated for many years, with or without failure, under severe conditions, due either to design or operation, which are known quantitatively. Only by combining analysis and experiment with service experience can design make real progress.

### CHEMICAL & PROCESS ENGINEERING

#### ENQUIRY BUREAU

Stratford House, 9 Eden Street, London, N.W.1

Readers requiring names of suppliers of raw materials, machinery or finished products should complete this form and attach it to their business note-heading. Please state approximate quantities required.

We wish to know names and addresses of suppliers of the following :

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